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Commercial fruit

PREFACE

I have read in considerable detail the manuscript of the handbook on fruit culture, "Commercial Fruits of India," written by Dr. Cheema and Mr. Bhat. I consider that it is interesting, up to date in its information and likely to prove a very considerable contribution to fruit literature of India, and in particular Western India. It is fully worth publication. The additional step of co-opting Mr. K. C. Naik, Horticulturist of Madras, who has had several years of experience in the Punjab and Bihar, has undoubtedly increased the All-India value and usefulness of the publication. In fact, it will become a standard horticultural book in so far as India is concerned.

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3249
Commercial fruit..

AUTHORS' PREFACE

This book on the major fruit crops of India describes chiefly the existing practices of fruit growing in its important aspects as they prevail in this country and more particularly in Western India. The fruit crops dealt with in it are banana, mango, citrus, guava, pomegranate, papaya, grape, sapota, fig and jujube. The information given in these pages is collected over three decades of work in the field of improving and developing the fruit industry in different parts of the country, mainly in Western India. Wherever possible, effort has been made to include an account of comparative practices prevailing in other tropical countries of the world.

Historically, fruits are found to have figured very prominently in the life of Indians from times immemorial. Jawaharlal Nehru ("Discovery of India", The Signet Press, Calcutta, 1946) states that as far back as the fourth century B.C. and even earlier in the pre-Buddhist period, horticulture was a prominent avocation in India. He quotes Ratilal Mehta to show that mango, fig, grape, banana and date were the favourite fruits of those days and that horticulture was practised on an extensive scale.

In A.D. 64, a Chinese embassy came to India and some welcome gifts brought to India then, according to Nehru, were the peach and pear trees. Later in A.D. 671, I-tsing (or Yi-tsing) visited the country as a pilgrim and "he tells us that fruits were abundant in India in those days". The same view was recorded by Paes, a Portuguese who, states Nehru, came in 1922 after visiting the Italian cities of the Renaissance, and remarked of the city of Vijayanagar—"it is full of fruit". Poets of front rank like Amir Khusrau, a Turk who settled in the U.P. and lived in the fourteenth century and a scholar in Persian, Hindi and Sanskrit, wrote poems on many subjects in which India excelled, including the mango fruit. All these together with the large-sized *lakh-bags* (orchards planted to 1,00,000 trees) established by Mughals and other lesser known Nawabs and Rajahs, all speak of the love for fruits that had permeated the Indians from the remotest periods of history. This is further borne out

from the fact that fruit is sanctified by religion and forms the principal food advocated by sages and saints and for use as offerings in temples and to men of light and learning. It is a paradox that notwithstanding this hoary past, fruit cultivation should still be an uncertain and risky avocation to those who resort to it and that fruit production should remain yet a hobby rather than be among the leading industries of the country, for fostering which nature seems to have contributed all that is congenial. Of all the limiting factors in the progressive prosperity of fruit culture, absence of a fund of tested and recorded information appears to be the most important. Fruit research being yet in its infancy, the fruit grower was largely allowed to plough his lonely furrow. Making the accumulated knowledge from observation and research available to growers, is a task of no small importance in any country, but is one of unexcelled value in India.

The subject of fruit growing in India did not receive until lately the attention of the State and the public which it deserved. In spite of the existence of a variety of conditions of soil and climate suited to the production of various fruits, India imports every year nearly three crores of rupees worth of fruits and fruit products both by sea and land. During the last quarter of a century, however, what with the influence of the agricultural and industrial depression which has swept over the world during the 'twenties and 'thirties, and what with the stimulus given by the Indian (formerly Imperial) Council of Agricultural Research, and some of the Provincial Governments and Indian States, a considerable awakening has resulted in this country towards the possibilities of fruit growing as an economic proposition. The valuable place that fruit occupies in a well-balanced diet because of its rich mineral and vitamin contents is being increasingly realised on all hands, and "Eat more fruits" and "Grow more fruits" are gradually assuming an importance as popular national slogans in this country.

Fruit research stations are now established in a few Provinces and States. Intensive work is being undertaken on fruits on which this country still maintains a monopoly production and also on other indigenous and exotic fruits of well-known varieties with a view to place the fruit industry on sound modern lines. Introduction of new varieties, isolation and

selection of the choicest indigenous fruits, improvement in the various cultural practices, control of diseases and pests, marketing, storage and preservation, as well as export are being tackled by workers at these research stations. Some of the Universities have also given this subject of fruit culture and preservation the prominence and status of a major subject in their agricultural teaching courses. As a result, the erstwhile haphazard system of fruit farming is rapidly giving place to improved, systematised and scientific methods of culture.

The present age is characterised by a steady drift of the educated among the rural population towards the urban areas as a direct result of various sociological factors, most important of which are the low values offered for farm products and the lack of recreation facilities. The high prices ruling after World War II have, however, altered these conditions considerably. Fruit growing, if carried out on right lines, offers the much needed diversification in agricultural farming, and has a special appeal to the best among the educated young men and retired officers and businessmen, both from the point of view of income and hobby.

The absence of literature on fruit culture has been felt as a serious void in this country. This is considered, therefore, an opportune moment to place before the fruit-minded public an account of the existing situation of fruit cultivation in this country. It is with a view to meet a long felt need that this book has been attempted.

In presenting this volume to the public the aim of the authors has been to put together matters of direct practical value to the fruit growers both present and prospective, in order to help them to make the profession an economic success. In its present growing stage, past conventions typified by the "rule of the thumb" methods are being subjected to critical tests and new theories and recommendations are accepted with considerable circumspection. The grower who is enthusiastic in his profession and eager to apply the latest available knowledge of the subject will, it is hoped, find in this volume a handy guide-book for day-to-day use. The book is also meant to acquaint the research worker with the existing methods and practices, so that he may plan the most fruitful lines of approach to the problems facing the industry in its present state. The student who

has to study the subject for his examination in the agricultur colleges and other institutions, and the general reader, wh takes interest in the economic development of the countrysi and the improvement of the national dietary, will also, it hoped, find the information presented herein of some help ar guidance. The authors have endeavoured to make each chapt self-contained as far as possible. With most of the fruits dea with in this book, several aspects of culture, propagation, et necessarily possess a high degree of similarity. This fact e tailed some repetition while treating subjects of, more or le common concern to more than one fruit. In the interests the reader, who may find it more convenient to have all ava able information on a particular fruit presented at one place, has been decided to retain the order of presentation as it stan at present, even though it has meant at certain places a degree repetition. If this volume proves of some service to these vario classes of people, and helps to attract more educated peo to the rural parts of this vast country, the authors will consid their labours amply rewarded.

Since the compilation of this book was undertaken, t books dealing mainly with the regional fruit producti practices of the U. P. and Madras have been brought o One is by W. B. Hayes of Allahabad and is entitled "Fr Growing in India" (Kitabistan, Allahabad, 1945), and other is on "South Indian Fruits" (Varadachary & Co, Madr 1949) by K. C. Naik who is also one of the authors of present book. These publications are a happy indication the endeavour to meet the growing demand for information this subject.

The authors are grateful to Dr. Ronald G. Hatton of East Malling Research Station and Sir R. G. Allan, reviewing the manuscript. The authors are thankful to D. Akenhead for helpful advice and in collaboration w Mr. C. St. C. Fielden of the East Malling Research Stat for reading it through.

In addition to various periodicals and publications list in the bibliography, the authors have drawn freely from a nu ber of books such as "Manual of Tropical and Sub-trop Fruits" by W. Popenoe, "The Book of the Mango" by Burns and S. H. Prayag, "The Cultivation of Cit

uits" by H. H. Hume, etc. Many of the tables of analysis fruits are taken from "The Structure and Composition of ods" by A. L. Winton and K. B. Winton. The authors knowledge their indebtedness to all the authors of these books d their publishers.

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Agricultural Research and includes a great deal of exp
gained through such research schemes. There are in
a large number of references to the works publish
scientists working all over the world. This book, th
represents the sum-total of efforts from a large num
horticulturists in the country, and the authors do no
therefore, to make any apology for presenting the work
fruit growing public. They will, of course, appreciate i
one of the readers will kindly point out any errors that
have inadvertently crept into the various references cited
text, so as to enable them to correct such mistakes in
revisions of this book.

G. S. CHEEM
S. S. BHAT
K. C. NAIK

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BUNCHES OF THE CHIEF BANANA VARIETIES OF WESTERN INDIA.

R. to L. : RAJELI, SAFED VELCHI, BASRAI, LAL KELA,

Chapter I

BANANA (*Musa species*)

One of the most popular fruits

The banana is considered to be one of the most auspicious plants in India. It has accordingly enjoyed universal popularity in this country from time immemorial. In recent years, banana has also been found to be among the most valuable crops for implementing the drive for increased food production, claiming in well-kept plantations an annual yield even up to 60,000 lb. per acre. It can well rank, therefore, with any agricultural or horticultural crop as the most efficient means of enhancing food production. In a densely populated country like India where suitable land for cultivation is by no means available in unlimited extent, extension of banana plantations will provide perhaps one of the easiest methods of exploitation of land for making the country advanced on the road towards self-sufficiency in food production. It is not only the ripe fruit of banana that is prized as a food: the central core of the pseudo-stem, the inflorescence and the immature or unripe banana fruits are also no less prized as sources of food in Indian households. In parts of South India, banana leaf forms an invaluable substitute for dining plates. In the floral trade and even in small scale textile industries, banana fibre has been used fairly extensively. On all these considerations, banana can be regarded as a fruit of value, both for the rich and the poor.

Origin

The original home of this tropical fruit is considered to be the Malayan Peninsula or its neighbourhood. It has also been suggested that the banana might have originated in some parts of the tropical forests of Asia. The cultivation of banana has now extended to many parts of the world, although it is limited to the tropics. The fruit has become so popular and is so widely used that it is now available in all countries of the world, wherever transport facilities exist.

One of the botanical names of the banana appear have been based on the legend that the serpent, which tem Eve in the garden of Eden (Paradise), hid in a bunc bananas. "Apple of Paradise", "Adam's Fig" and the spe name *paradisiaca*, all appear to have a distinct relation to cient mythology. The word "banana" is said to have b adopted from an African Congo tribe.

Commercial importance

The commercial importance which this fruit has gained be judged from the fact that its consumption in the Un States of America and the European contin is enormous. The Islands of Honduras a Jamaica are among the chief banana export countries of the world. Brazil has also entered the competit and her exports have increased rapidly in recent years. T world trade in banana has been more than doubled during last thirty years or so. Before World War I, it averaged sligh over a million tons of fruits or about 60,000,000 bunch annually. The total export trade of banana in the year 19 amounted to about 2,000,000 tons of fruits or abo 115,000,000 bunches. But there was a slight decline in 1931.

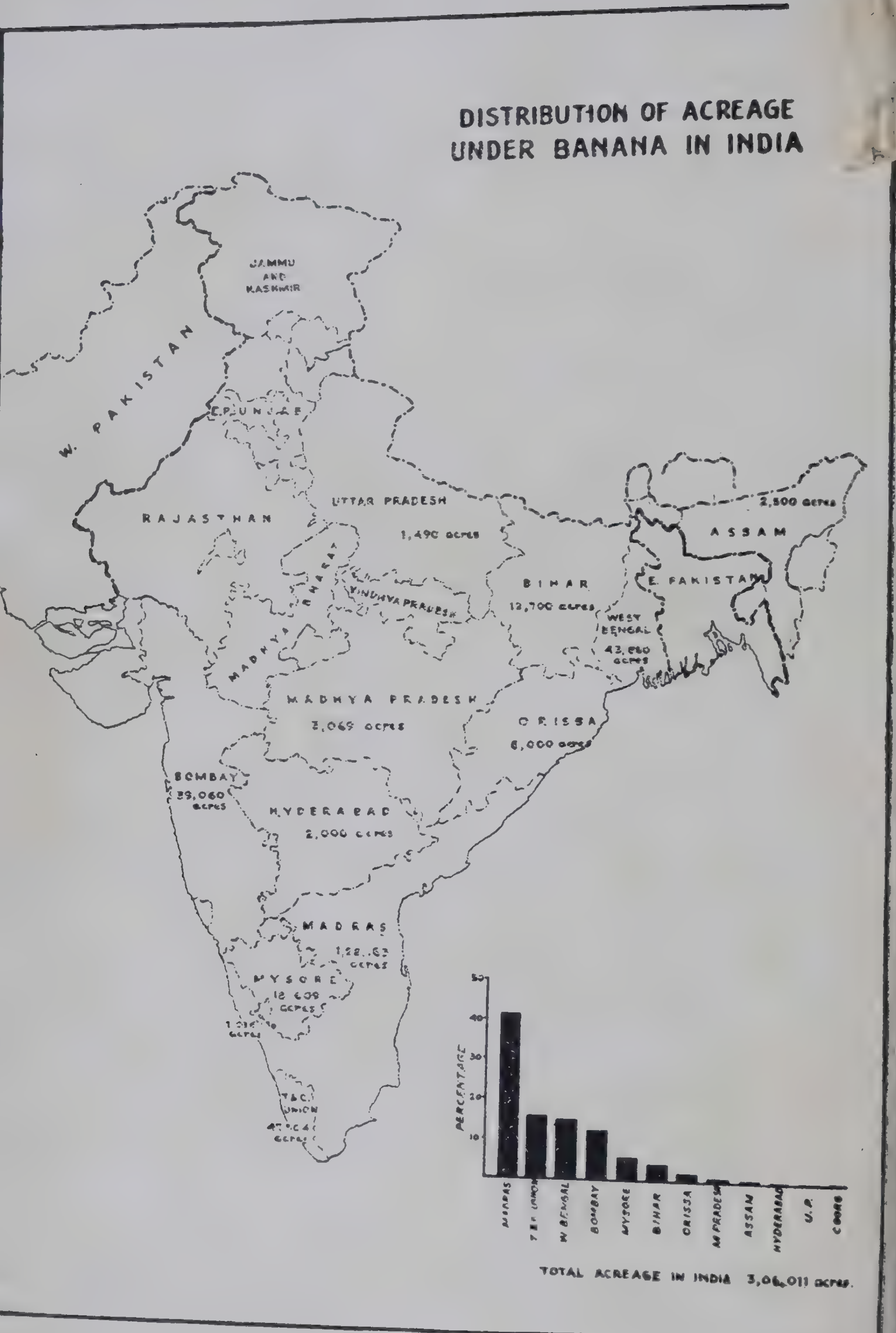
World production of bananas for overseas export duri 1937 was more than 2·5 million tons. This was concentrat mainly in Central and South America and in the West Indi with Jamaica as the largest single producer, Mexico being th second largest.

Sierr (84) gives an account of the plantation of the Unite Fruit Company at Tiquisata, Guatemala, with an acreag of 125,000 hectares and said to be the most modern and large banana estate in the world.

The leading countries importing banana are the following:

United States of America	1,210,000	tons
United Kingdom	272,000	,,
France	111,000	,,
Japan	92,000	,,
Germany	87,000	,,
Canada	69,000	,,

High class varieties like the Gros Michel or Claret, which slightly differ from the Indian commercial varieties, hold the monopoly of world trade of bananas.


DISTRIBUTION OF ACREAGE UNDER BANANA IN INDIA
JAMMU AND KASHMIR
W. PAKISTAN
E. PUNJAB
RAJASTHAN
UTTAR PRADESH
1,490 acres
VINDHYA PRADESH
BIHAR
12,700 acres
WEST BENGAL
43,680 acres
E. PAKISTAN
ASSAM
2,500 acres
MADHYA PRADESH
3,069 acres
ORISSA
6,000 acres
BOMBAY
39,060 acres
HYDERABAD
2,000 acres
MADRAS
MYSORE
12 609 acres
T&C. UNION
PERCENTAGE
50
40
30
20
10
MADRAS
W. BENGAL
BOMBAY
MYSORE
BIHAR
ORISSA
M PRADESH
ASSAM
HYDERABAD
U.P.
TOTAL ACREAGE IN INDIA 3,06,011 acres.

s stated above, the banana which originated somewhere e tropical forests of Asia—in the Malayan Peninsula or

Distribution

the neighbouring countries—is now extensively cultivated under a variety of soils and climates in Jamaica, Costa Rica, Cuba, Honduras, northern shores of Columbia, Central America, Canary Islands and the West Indies, besides the Indian Union. These countries, excepting India, export banana to the European countries throughout the year. Most of the other tropical countries too grow banana to a limited extent to supply their own local demand for the fruits as in India.

The chief regions in India which grow banana extensively are Madras, Travancore-Cochin, West Bengal and Bombay

Chief growing regions in India

States. The total area under banana in India is 306,011 acres according to latest available data. It is mainly distributed as follows:

1.	Madras	128,163	acres
2.	Travancore-Cochin	47,504	,,
3.	West Bengal	43,880	,,
4.	Bombay	39,060	,,
5.	Mysore	18,609	,,
6.	Bihar	12,700	,,
7.	Orissa	6,000	,,
8.	Central Provinces	3,069	,,
9.	Assam	2,500	,,
10.	Hyderabad	2,000	,,
11.	U. P.	1,490	,,
12.	Coorg	1,036	,,

306,011

enerally speaking, there are three distinct regions in India respect of production and consumption of bananas. The orthern and the North-Western parts constitute essentially onsuming centres, while South India, North-Eastern India nd the Bombay Presidency comprise the main producing reas. The rest of India produces limited quantities of banana hich are either sufficient for home consumption or have to be artially supplemented by imports.

The prevalence of frost and severe winter conditions preude extensive cultivation of bananas in parts of the North and orth-West India, particularly near the foot of the Himalayas.

employed by some, has been dubbed as "taxonomically unsound" by Cheesman. Dodds and Simmonds (42), have proved that the name *M. sapientum* of Linnaeus was applied originally to an interspecific hybrid. This lends force to the argument that *M. paradisiaca* should stand as the correct name for edible bananas.

All over the world, however, the term banana is now widely accepted as the trade name for all edible varieties of the fruit. In South India, on the other hand, all varieties are designated under the group name of plantain. Originally, the word banana was commonly applied to the varieties which are eaten raw and plantain to those which are eaten after cooking. Pope (76) also does not consider that any such clear differentiation exists at present. In accordance with the almost universal usage it seems appropriate that banana should be used for all edible varieties, whether they are used for table or cooking purposes.

The most important commercial varieties of the Bombay Presidency are briefly described below:

(1) *Mindoli* (*Mhaskel*):—Tall plant, bearing bunches with about fifty thick-skinned yellowish fruits, having three clearly marked edges on them. Fruit not suitable for export.

(2) *Rajeli* (*King banana*):—Robust tree, with yellowish green stem and long narrow leaves. Fruit usually eight to ten inches long and one to one and a half inches in diameter, yellow in colour, and plano-convex, gradually converging to the stalk. Tip of fruit contracted with a distinct hard brown beak. Extensively grown in Bassein and well suited for drying purposes. The commercial product *Sukeli* (sun dried banana) is prepared from this variety.

(3) *Soni* or *Sonkel*:—Tall plant, with sparse leaves and reddish tinge on both sides of peduncle; fruit sweet and not easily separated from the stalk; has good keeping quality.

(4) *Velchi*:—Tall plant, with fruit tapering towards the stalk, and slightly sour in taste. Fruit small in size and yellow when ripe. Skin very thin and

IES OF LEADING COMMERCIAL VARIETIES OF SOUTH INDIA
POORAN (2) RASTALI (3) NENDRAN (4) MANTHAN AND
(5) SIRUNIALI.

: K. C. Jacob, Assistant Systematic Botanist, Coimbatore.) *Facing page* 6.

BUNCH OF RASWEL BANANA. *Facing page 6.*

BUNCH OF RAJAPURI BANANA.

Facing page 7.

papery, pulp whitish and highly agreeable; very delicious and high quality fruits. This is called *Safet* or white *Velchi* while a type approaching the *Sonkel* in quality is named *Lal Velchi* (red *Velchi*). The variety called *Mitka* in Karnatak is akin to *Safet Velchi*. The *Rasbali* which is a fair keeper and is a much superior variety is closely related to *Velchi* in morphological characters.

(5) *Lal Kel* (Bassein Red):—Tall plant, leaves very long and green with stalks of a dull purple tinge; fruit usually about eight inches long and 1·5 inches in diameter, oblong, cylindrical, slightly falcate, tapering slightly towards either end, beak hard, skin red and flesh yellow. One of the most popular types in the Bombay Presidency.

(6) *Basrai*:—Dwarf stem; leaves broad; skin yellowish green even when fruit is ripe; delicate, fruit long and uniformly thick; poor keeper.

(7) *Walha* (*Rajapuri*):—Dwarf stem; fruit short and thick near the stalk, tapering towards the beak; drops from the stalk easily when ripe; ridges distinct on the fruit; medium keeper and medium quality; pulp is stringy in the centre.

(8) *Mutheli* (Butter Banana):—Dwarf stem, with broad and short leaves; fruit medium, thick and round, bow-shaped, sweet taste; bunches thickly packed, fruit yellow when ripe; base of leaves very oblique.

In Bassein, nine varieties of banana are chiefly cultivated, d of these *Lal Kel* and *Lal Velchi* are the most popular. Of e, however, *Safet Velchi* is gradually gaining more demand. mmercially, *Sonkel*, *Velchi*, *Basrai*, *Lal Kel* and *Rajeli* are conered to be the choicest dessert varieties in Western India.

Of the numerous varieties grown in the Madras State, *Poovan* n. *Karpura Chakrakeli*) is easily the most important from the nmercial point of view, accounting for about 70 per cent of total production in southern districts. On the Malabar st, *Nendran* is the most popular variety, while the *Sirumalai*, fruits of which have fine flavour and taste and good keeping

quality, is largely grown on high elevations. *Monthan*, *Mau tius*, *Rasadali* (syn. *Rasthali*), *Pacha Nadan*, and *Bontha* com prise the other important cultivated varieties in the centr and southern parts. Of these, *Monthan* and *Bontha* a grown for culinary purposes. In the Godavari, Ganjam ar Vizagapatam districts, *Chakrakeli* and *Karpura Chakrakeli* (sy *Poovan*) are the most popular table varieties, while *Month* and *Bathisa* are grown for cooking purposes.

The *Nendran* and hill bananas are noted for long commerci storage life, keeping well for about 15 days after harvest. Th former variety can be dried, and is also used largely f making chips, several kinds of sweets, as well as for preparin jelly, jam and preserves. It bears the largest sized fruits, an because of this character it is considered locally to be poor man's meal. *Poovan* and *Mauritius* keep well for about week, as also the *Rasthali*, which is, however, unfit for expo trade purposes as fruits shed easily from the bunches, whi *Mauritius* fruits get slightly discoloured in transit. *Rasthali* considered to be one of the popular table varieties in some par of South India for its fine flavour and taste, but it has a meat pulp with a tendency to form hard lumps in flesh. The whit *Chakrakeli* is a greater favourite among the consumers in th northern parts of South India. Because of its hardiness, hig yield and fair keeping quality, *Poovan* commands popularit both among growers and tradesmen and, therefore, claims th largest area in the South. *Monthan* is also a good keeper, b being of poor quality and fit only for cooking, it does n command as much market value, except close to urban area *Chakrakeli*, though very highly esteemed for fruit quality, not very adaptable and is difficult to grow under adverse con ditions of culture, climate and soil.

Kaio, a Hawaiian variety of banana, has been introduce into South India and is being grown in the Banana Experiment plot at Coimbatore. The fruit is 6·5 inches long, oblong spindle shaped and resembles *Nendran* the Malabar Banan in respect of taste and flavour.

Champa, *Decca*, *Murtaban* and *Pankela* are the main comme cial table varieties in Northern India.

A wild banana, *Musa superba*, is also seen growing in man forest areas. In Bihar, Eastern Himalayas, Assam Hills, Man

ır and Burma, this type is seen growing wild. Its fruit is full seed and is not edible. It is chiefly used for its leaves by the cal wild tribes.

The *Musa Fehi* Bert variety is reported from the Tahiti lands (17). This species is easily distinguished by its erect unches, which never droop as in the other species, a feature said be met with also in the banana *Kusaie* of the Hawaii Island.

Some types of bananas like *Musa textilis* L. Nee, are ell known for their fibre, popularly known as the Manila hemp.

›il

For its successful cultivation, banana requires a rich loose il. The sandy soils of Bassein and the coastal tract of the North Kanara district are very well suited for its cultivation. In the Konkan, most of the ılleys in the ghats (mountain ranges), where water supply is lenty, atmosphere is damp, and humus in the soil is sufficient, e found to be very favourable for the banana to thrive. In eavy, ill-drained and shallow soils, the banana is often a prey the Panama disease, caused by the fungus *Fusarium oxysporum* ar. *cubense*.

At Walha in the Bombay Presidency, banana is grown in ack cotton soil, about four to five feet deep. This soil is well ained being situated on the banks of streams and nallas. he banana crop in such a soil is, however, not as productive in the sandy soils of Bassein. The medium black and lighter ils of Khandesh are also used for planting banana, provided igation facilities exist.

In the Presidency of Madras, banana is grown under a riety of soil conditions from the heavy clay but well drained ils of some of the deltaic tracts of Godavari and Kistna to the ghtly open or loamy slopes of the Lower Palni hills. The gin lateritic lands on the hill slopes of the Malabar coast, e alluvial or heavy loam of the wet paddy lands in most of the stricts, and the alluvial soils along the Cauvery banks as well the garden soils of various composition in Coimbatore, all opear to suit the crop, provided good drainage and heavy oplication of manure are provided for, especially in soils deficent in fertility. Banana plantations of nearly a hundred years age are found thriving along the rich banks of Cauvery river the Tanjore district and near Aduthurai.

Dunlop (8) opines that bananas do not grow on saline

soils, which prove dangerous if the salinity exceeds 0·05 per cent. Damage caused to banana plants depends upon the soil texture and the salt concentration. The optimum soil texture is reported to be as follows:—

Sandy loam	0·03 per cent.
Clay loam	0·045 ,,
Medium clay	0·050 ,,
Heavy clay	0·070 ,,

Soils which are best suited for banana have a fair quantity of lime and humus. Alkaline lands are said to improve by growing banana on them. Richly manured fields as in the cases where betel vine plantations existed previously produce good crops of banana, even without additional manuring for about two years. If the soil is stiff clay, it is loosened by the addition of village earth and sand. Rich scrub soils and soils with plenty of humus and free from excess of salts are very good for this crop. In general, banana is rather exacting in its soil requirements, and one has to go into the details of the soil selected before planting. A soil which is about two feet deep with a porous subsoil constitutes the minimum requirements for successful banana cultivation.

Climate

Banana is essentially a tropical plant and grows in warm humid climates better than in cold dry climates. Tracts where there is a chance of frost occurring during the winter, are not safe for its cultivation. Low temperature damages or kills the plant tissues and hinders the development of the fruit, affecting its quality. The district of North Kanara is perhaps the most ideal region for the cultivation of banana in the Bombay Presidency. But due to lack of irrigation facilities and means of transport and marketing, the cultivation of banana in this district is not as extensive as it deserves to be.

Taller varieties as a rule seem to flourish in warmer and moist climates than in cooler and drier climates. The loss due to high winds can be minimised in the case of tall varieties of bananas by planting thick wind-breaks. *Euphorbia tirucalli*, Linn and *Sesbania aegyptiaca* Pers, make useful wind-breaks in the Deccan. *Dalbergia sissoo*, Roxb. can be used as an effective wind-break in Sind. In the Khandesh dis-

tricts temporary wind-breaks of dry *tur* stalks (*Cajanus indicus* Speeng) or other similar material are erected on the western and southern sides of the plantation to cut off the hot wind from scorching the banana plants during summer, especially where irrigation water is scanty. *Lal Kel* does not seem to display its original attractive characteristics when grown in the dry districts above the ghats, and perhaps on this account, it is also observed to be a very poor yielder in the Gujerat tract.

During the years 1925, 1929 and 1934 most of the banana crop in the central Deccan districts was destroyed by the severe frost, though the cold wave lasted only for a short period, each time. The temperature went down to below 35°F in shade at many places and in some cases it reached the freezing point. It is observed that some types of banana are slightly more resistant to frost than others, but when temperature falls below freezing point, all types suffer equally badly. *Walah* or *Rajapuri* seems to resist ordinary cold better than *Basrai*. Leaves and tender stems of the *Basrai* got scorched and the growth of the plants was checked for about three months as a result of frost in the Khandesh district.

Like low temperature, strong wind is detrimental to the well-being of the banana plant. Very heavy winds may damage even the dwarf types of banana like the *Basrai* and *Walha*. In sheltered situations, however, the plantation may thrive well. It is chiefly on account of low temperatures during winter and high winds during the summer that bananas of good quality cannot be successfully grown in the Eastern Punjab and parts of the U. P.

Banana stands as heavy a rainfall as 150 inches or more per annum. About 70 to 80 inches of rainfall, if well distributed, is good for its cultivation. Heavy rain is not so injurious a factor to banana as low temperature, continuous strong wind or heavy clay soils. But if copious irrigation is available, the shortage of rains will not in any way discourage banana cultivation. Trenching of the planting area is found essential in heavy rainfall tracts, in order to drain away excess of water in the soil. Ordinarily, too much of stagnant water in the soil is injurious to the plantations. Stagnation of water encourages *Panama* and other fungus diseases.

Before planting suckers of banana, the land should neces-

sarily be well tilled. It is very beneficial to have the land deeply ploughed and heavily manured with farm yard manure. In Bassein, the land is flooded to soften the soil and a week later it is ploughed crosswise. This is followed by harrowing and levelling. In Bombay State the land is allowed to get heated for a few months. In May, *rabbing* (burning brushwood, etc., on the area for heating the soil) is done. With the fall of the first monsoon showers, the land is again ploughed, harrowed, levelled and planted. In the vicinity of Jalgaon, the land is well ploughed and harrowed before suckers of *Basrai* banana are planted.

Preparatory tillage

The spacing for planting varies with the variety as follows:—

	Spacing of Planting
Lal Kel	9-10 feet apart
Lal Velchi	8-9 ,, ,,
Mutheli	8-9 ,, ,,
Safet Velchi	8-9 ,, ,,
Rajeli	7-8 ,, ,,
Basrai	5-6 ,, ,,
Mhaskel	5-6 ,, ,,
Lokhandi	5-6 ,, ,,

It is found by experience that a spacing of eight feet is suitable for the purposes of interculture.

The size of pits taken for planting suckers also varies according to the nature of the soil. In heavy black soils, pits are generally larger and deeper, being sometimes as big as 1½ ft. by 1½ ft. each. In lighter soils, it is not necessary to have such big pits. Fawcett (46) opines that larger pits give a better growth in the start to the suckers than smaller ones do. In Queensland it is reported that bananas are planted 12 to 15 feet apart in the case of dwarf varieties, and 20 to 25 feet apart in the case of tall varieties.

Planting is done in the Bombay Presidency in furrows taken crosswise at a distance of 4½ ft. to 10 ft. each way. Small suckers are selected and planted at the crossing of the furrows in the pits already prepared. Irrigation follows, if it does not rain. Planting is generally done after the break of the rains. When the suckers shoot up, the furrows are broken by hoeing the land

crosswise frequently during the monsoon as the conditions of the soil may permit. Ten to fifteen cartloads of farm yard manure are added to an acre of land. After the rainy season, beds and water channels are again prepared and irrigation is resumed in beds between rows of trees, which are earthed up and thus supported by raising the soil at their foot.

In the Madras Presidency, 800 to 1,250 suckers are planted to an acre depending upon the variety. Along the Malabar coast (west coast of India) banana is often planted as an intercrop amidst areca-nut and cocoanut plantations. It is also planted as a shade crop for coffee and mandarin orange plants in South India.

In the drier tracts of Eastern Punjab, it is customary to plant bananas along with mango trees as shade or nurse crops. This practice is also prevalent in the Gujerat districts, in the early stages of mango plantations.

Banana is usually propagated by suckers, a large number of which spring up from the base of the mother plants. Suckers may be planted in the beginning of the monsoon, that is, in the months of June-July. The selection of good suckers for planting is an important item requiring careful attention of the growers as this operation largely influences the future plantation and the yield. It is difficult to define accurately the type and bulk of suckers, which may be considered good for planting. Suckers of the following type are observed by experience to be useful and to yield satisfactory results:—

Selection of suckers for planting

(1) Sword sucker which has a vigorous shoot, thick at the base and sharply converging towards the end with few linear leaves from which the name, sword sucker has arisen. Such suckers are preferred to ordinary suckers.

(2) Suckers less than three feet in height and selected from healthy and mature plants. These too are found superior as planting material.

Large suckers might bear fruit earlier than smaller ones but their bunches are generally small. It is, therefore, necessary to select small sword suckers, which are in a vigorous growing condition unlike ordinary or "water" suckers. Bowman (18) found that sword suckers produce the largest fruits.

Chona (36) has shown that to propagate healthy suckers it is necessary to separate from affected suckers the underground stem or corm which is usually free from infection, and plant the same after dipping in 2% copper sulphate solution. The secondary suckers coming out of such corms will be disease-free.

In some parts of the Madras Presidency, the suckers are hardened after they are separated from the mother plants by keeping them in the sun until they wither. In the Bombay Presidency, the selected suckers are headed back to about two-thirds their original length, their roots and buds are cut cleanly and they are then dipped in a thick slush of cowdung and water. Finely powdered old, wood-ash may be dusted on them. The dipping of suckers in cowdung and dusting them with ash is reported to protect them from rapid drying in the open field until they sprout up and begin to grow.

In the case of *Basrai* banana, however, very small suckers are chosen for planting, since it has been found to prolong the growing period and also increase the yield.

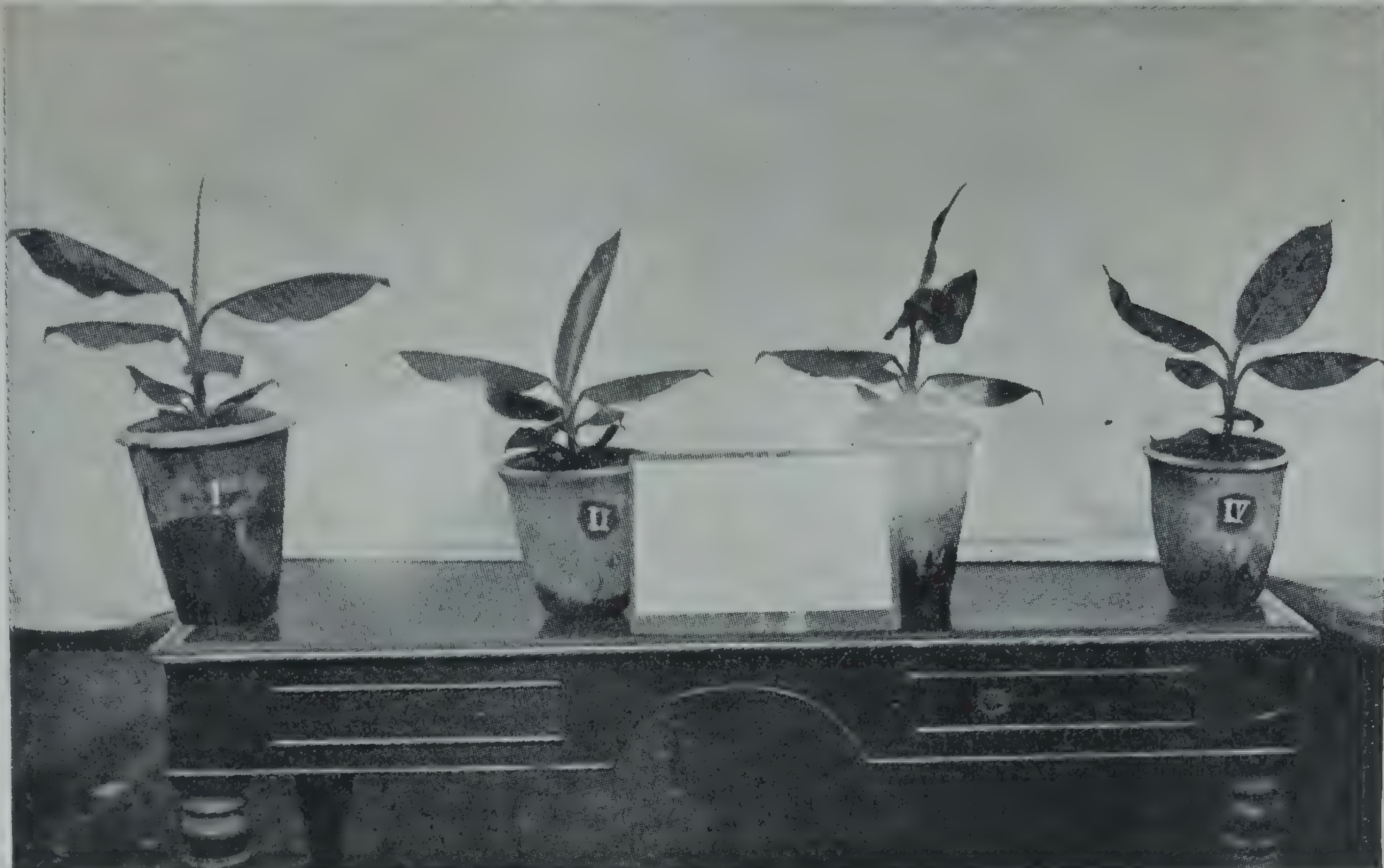
In Queensland, corms carrying two or three eyes only are used for planting (88). Bits, or rather sections, of old banana corms with one good bud are also used for planting.

In Brazil, banana soils after fifteen years of continuous cropping, are renovated by intensive cultivation, and the new plantings are made with bits of corm having two eyes planted on ridges (90).

In New South Wales it is recommended that suckers with the largest bulbs farthest from the parent, and with the most pointed and narrow leaves should be selected for planting. Those that are in the centre of stools, or have broad flat leaves known as umbrella or water suckers or those that are small and weak, and are found on stumps of the corm, are recommended to be discarded.

Planting

As has already been stated, planting is done in Bombay Presidency in July-August in pits, which are filled with soil mixed with a small quantity of farm yard manure about 5-10 lb. per pit. The soil is well pressed round the suckers and irrigation is given copiously. Suckers are planted straight. On planting the whole area may be flooded or water may be given in basins as required. After planting, water is given on the fourth and eighth days, if there is any



BANANA SEEDLINGS OF THE MANDRA BALE VARIETY.

Facing page 14.

SWORD SUCKERS OF BANANA USED FOR PLANTING, SHOWING STAGES OF GROWTH.
THE ONE IN THE CENTRE IS OF THE RIGHT STAGE OF PLANTING.

break in rains. Regularity in watering is essential for this crop. In Bassein no irrigation is given during the rainy season, but if the rains fail or the period between two successive rains is prolonged, the root zone is covered with banana leaves which form a mulch. The plants are hand-watered at the rate of two buckets (4 galls.) per plant at an interval of six to eight days.

Except during the rainy months, *Poovan* is planted in the Madras Presidency all through the year, some growers planting it in two or three seasons to take crop during the greater part of the year. The most popular planting season on the Cauvery delta is, however, February-March, but July to October plantings are also not unknown.

At Samalkota agricultural research station in the Madras Presidency, it has been found that planting of about six-week old suckers in May at a uniform distance of ten links overcomes the irrigation difficulties, met with in the case of the commonly prevalent method of planting in November (4). The latter plants are hand-watered for two or three weeks until the break of the south-west monsoon, and they mature their crop in ten or eleven months.

Banana is a heavy surface feeder. Not only does it require a copious supply of water but also heavy manuring. At Bassein

Manuring

(41) top dressings of the following mixtures are usually given after planting at regular intervals of one month for a period of three or four months:

Castor cake ..	.. 4-5 lb. per stool
Sulphate of ammonia	.. 1½ lb. ,, ,,
Sulphate of potash	.. 10-11 oz ,, ,,
Superphosphate ..	.. 11-12 oz ,, ,,

Other oil cake may also be given in addition to the above at the rate of 6-8 lb. per stool twice or thrice a year.

Different varieties of banana receive different doses of manure at Bassein. For instance, *Lal Velchi* is manured thrice at an interval of a month with 4 lb. of castor cake each time. At times, the third application is of fish meal and castor cake at the rate of 5 lb. and 2 lb. respectively. *Lal kela* (Bassein Red) plants receive four doses at intervals of three weeks each as follows:—

1. 4 lb. of castor cake
2. 6 lb. of castor cake
3. 5-6 lb. of fresh fish and 2 lb. of castor cake
4. 4 lb. of castor cake if the bunch is well developed, or else 6 lb. of fish instead.

Near Jalgaon where banana plants receive sewage water, no other manures are usually applied.

In the northern parts of the Bombay State, a heavy dose of some quick acting manure is applied after the monsoon breaks, and after the plots are weeded and the dry leaves of the plants are cut off. Groundnut cake at the rate of 2-3 lb. is recommended by some in Madras as the nitrogen in this cake is said to be more readily available than in other oil cakes (96). Other oil cakes and fish guano are recommended in places where they are cheap. A popular manurial practice in the Cauvery deltas is to apply sulphate of ammonia at 224 lb. per acre in April-May, about two months after planting. This is followed by an application of 1,000 lb. of groundnut cake and 224 lb. of ammonium sulphate or ammophos in the fifth or sixth month. The third or last application is done in the ninth month, and this is similar to the first. Trenches 15″ wide and 9-12″ deep are opened between every two rows, and the earth thus dug out is spread over the beds along the rows of trees. According to another system prevalent in these parts, a light dose of 1/2 lb. groundnut cake is applied around each plant soon after the plants begin to grow; and 5-6 weeks later, another application of 1½-2 lb. of the same cake is made. Good crops have been obtained in some parts of the Bombay State by the application of 20 cartloads of farm yard manure and 1,000 lb. of sulphate of ammonia per acre.

In the case of the *Walha* variety, the usual practice is to apply farm yard manure and sheep dung. After the first ploughing, about ten cartloads each of cattle manure and of sheep dung are applied and harrowed in. Later on, about 40 lb. of cattle manure are applied per stool at an interval of six months. Sheep dung is applied only once in the beginning of the plantations.

At the Ganeshkhind Fruit Experimental Station, Kirkee, manurial trials have been conducted on the *Basrai* variety of

bananas on a large scale, with a view to ascertain its requirements under the Deccan conditions of soil and climate. The method of layout adopted for these trials was the Latin Square, and the manures excepting in the case of potash were apportioned on their nitrogen basis. These trials included the use of farm yard manure as the base; and sulphate of ammonia, castor cake, bone meal, potash and double dose of farm yard manure were used. Different manurial combinations were tried and it was found that the application of 5 lb. of castor cake per stool in conjunction with 40 lb. of farm yard manure was the most suitable for the crop.

In parts of South India where rice is grown in rotation with banana, some growers also apply a basket of rich organic manure to each stool of banana at the end of the third month after planting. About 40 cartloads of farm yard manure per acre is considered to be a suitable quantity by some, and it is applied about a month after planting. In the absence of farm yard manure, about 1,500 lb. of groundnut or other oil cake per acre have also been applied in some places. Tannery refuse mixed with farm yard manure is considered by still others to be of value for bananas.

If circumstances permit it is advisable to green manure the land before digging pits. Green manuring is good both in heavy and light soils. The banana being a surface feeder, addition of humus to the soil helps to encourage the growth of the plants and increase the yield subsequently.

For thriftless banana plantations in Trinidad an application per tree of 200 lb. of synthetic pen manure with or without one pound of muriate of potash was found to be beneficial (95).

Fawcett (46) recommends the mixture of the following manure for banana:—

1.	Sulphate of potash	..	344 lb. per acre
2.	Wagner's double phosphate		211 lb. ,, ,,
	or		
	Mineral superphosphate	..	530 lb. ,, ,,

This mixture is applied at the rate of 400 to 600 grammes (1 lb. to $1\frac{1}{2}$ lb.) per plant, varying with the kind of phosphatic manure used in the combination. Care should be taken

to place the manure in a trench made around the stem, avoiding direct contact with the stem.

Bartlett (14) states that banana is a voracious feeder and it is essential to keep up the fertility of the soil by every possible means. Supply of humus to the soil is indispensable as this manure not only provides plant food but also retains moisture and improves the aeration of the soil. It creates favourable conditions for soil bacteria to act upon mineral matters, thus rendering plant food easily available. He further states that experimental tests have demonstrated the usefulness of the mixtures given below:—

1. 2 lb. of dried blood,
   1¼ lb. superphosphate,
   1 lb. sulphate of potash.
   } per stool every six months.

2. 1¼ lb. sulphate of ammonia,
   1¼ lb. superphosphate,
   1 lb. sulphate of potash.
   } per stool every six months.

Either of these mixtures can be applied in March and in October to every stool.

In Grenada heavy soils are found to need liming as they retain moisture and become acidic in reaction. Soils with pH value of 6·5 require one to two tons of hydrated lime per acre.

Irrigation

The banana plants require very heavy irrigation. A local proverb is current that "the banana plant asked for water to drink, when it was being carried away by the river flood." Apart from this exaggeration, it has been observed that on an average the plants require about 3 acre inches of water at each turn of irrigation in the hot months from February to May (2). Irrigation is given in most places once in eight to ten days. Stagnation of water in soil is not very congenial to the proper growth of the banana plant. Drainage of the soil is, therefore, essential for its successful cultivation. It is seen that in heavy soils, banana plants thrive better on raised ridges alternating with trenches, than in flat beds. Near Jalgaon, irrigation is given to banana plants every three or four days during the hot weather. After the rains, irrigation beds are prepared between the rows of plants and irrigation intervals are reduced with the approach of cold weather.

In the Godavari delta area, irrigation is applied in trenches after the rainy months, usually once in seven to ten days depending on weather conditions. In parts subject to cyclonic weather, propping is essential and this should be provided before the monsoon sets in or irrigation is given. In perennial banana plantations or on rainfed hilly areas, no irrigation is given to the crop, but in the former case water may be let into drainage trenches to reach the brim, so that the feeding zone of roots gets moistened through radial spread of moisture.

The bananas in some countries are irrigated at intervals of fifteen days from February to May and receive approximately 5 acre inches per turn. This procedure is adopted in plains where the annual rainfall is about 60 inches only.

In the opinion of Fawcett (46) "irrigation after flower forming will not affect the number of fruits in the bunches." Water channels close to the suckers are beneficial in the earlier stages of growth, but it is advisable to shift them a little away as the plants advance in growth, as proximity of water channels only encourages the production and growth of suckers which may not be desirable in cases where only the mother sucker or a few more are allowed to flower.

An experiment to determine the water requirement as well as to see the effect of ridge planting of banana was carried out at the Modibag gardens at Poona. Banana plants were planted on ridge with trenches opened by their side at a distance of three feet. The trenches were two feet deep. The following table shows the details of the performance of plants on the ridges as compared with that of plants in level beds by their side:—

Ridge vs. level planting of banana

System.	Average girth of plants in inches at base.	Average height of plants in ft. and inches.	Weight of fruit per bunch. lb. oz.	Number of fruits per bunch.	Total number of bunches harvested during the same period.
Flat bed	25	6-8	15-8	80	39
Ridges & trench	28	7-3	24-0	93	61

It will be seen from this table that the superiority of the trench and ridge system is established, although it requires a larger quantity of water. The actual quantity of water given in flat beds was 3·23 acre inches, while it was 3·30 acre inches in the trenches per irrigation turn. These trials were conducted with the *Walha* variety of bananas grown in medium black soil. On the light soils which are usually well drained, the bed system also works well but the frequency of irrigation has necessarily to be greater. It is noted that the interval of irrigation depends upon the nature of soil and weather conditions, and it can be adjusted to five to six days during summer and eight to ten days during the other seasons. In very light soils this interval may be of four days only.

The advantages of irrigating banana stools in trenches may briefly be summarised as follows:—

Advantages of trench irrigation

1. The average weight of fruits per bunch increases by about 55%.
2. The number of fruits per bunch increases by about 16%.
3. The plants grow and mature quicker, and a larger number of bunches can be harvested during the same period from an equal area than in flat beds.
4. Labour and water charges are low.
5. Damage due to fungus diseases is minimized.

Heavy irrigation encourages diseases

The banana plants are planted very close compared with most other fruit trees and whichever system of irrigation is adopted, it would practically amount to flooding the area. On ill-drained soils, heavy irrigation encourages the occurrence of the dreaded Panama disease caused by the fungus *Fusarium oxysporum* var. *cubense*, and the crown rot caused by *Fusarium moniliforme* var. *subglutinens*. However, the system of irrigating banana in trenches as explained above keeps the banana stools fairly above the level of water, unlike in flat beds, thus lessening damage due to these diseases.

The *Basrai* and the *Walha* are the chief commercial varieties of banana grown in the Deccan. Fruits of *Basrai* are sent to several parts of India including the Punjab and the North-West Frontier Provinces from the Khandesh districts and Bassein. The *Walha* is chiefly used for the local markets of the Poona district. From the market point of view, the Basrai is the better and superior type as its fruit is bigger and sweeter, though it is a poor keeper. A trial was conducted at the Ganeshkind Fruit Experiment Station, Kirkee, to find out the comparative economic value of these two varieties to the grower. It was found that the first bunch of *Basrai* gives higher yield than the *Walha* variety, other conditions being equal. As to whether in the long run the *Basrai* or the *Walha* will prove more economic to grow, is a subject yet under investigation.

Banana variety trials

The fruiting period in the banana varies in different varieties and seems to be considerably influenced by the quality and size of the suckers selected for planting as well as the climate. *Basrai* generally fruits in fourteen months. *Walha* requires about ten months, while *Velchi* and *Son Kel* take twelve months. The fruiting age from planting apparently is also closely related to the size and age of the suckers while planting. It is believed that the larger the suckers, the shorter is the fruiting age from planting. But in such cases the yield of fruits is generally less.

Fruiting of bananas

It has been reported that in the Godavari district of the Madras Presidency, bananas generally make the maximum growth during the rainy months of July to November and it takes nine to thirteen months to throw out bunches from the date of planting. Flat sided fruit varieties in general, seem to take a much longer time to bear fruits than the round fruited ones. The number of days taken from flowering to harvest of fruits varies widely, apparently depending upon the variety and season of flowering. Maximum production of the *Poovan* variety is noticed from December to March, of *Rasthali* from April to May, of Mauritius from October to November, and of hill bananas almost throughout the year. In Madras and Bombay bananas are generally available in local markets throughout the year, but June to October and December to March seem to be the two periods when trade is the busiest.

The number of hands per bunch and the number of frui per hand are both varietal characters, but the early formed hand have been invariably found to record higher weight per fruit (74 It may be observed that ripening and rotting are processes tha are hastened markedly when bunches are cut into hands tha otherwise.

In the case of *Basrai* and *Lal Kel*, only the sucker whic is planted is allowed to flower in Bombay State. All sid suckers are pruned off as soon as possibl after they appear, in order to give bette facilities of growth to the mother plant In *Walha*, *Lal Velchi* and *Son Kel*, more side suckers are allowed to grow and flower. At Bassein and near Jalgaon, however, there is a tendency to have only the mother plant to flower in all varieties. Where only one sucker is allowed to flower and fruit as in the case of *Basrai*, the life of the plantation is limited to about eighteen months. In other cases, the plantation may be prolonged for several years, without being replanted, as sucker after sucker will be allowed to fruit in the same stool. In *Basrai* the later suckers are extremely poor yielders and hence the practice of allowing only the mother plant to fruit. The local practice in some parts of the Madras State is not to remove the suckers at all from the plantation when once it is raised and the crop is treated as a perennial one. Plantation of about a hundred years of age or over are not unknown even today. In perennial banana plantations in South India, the mother plant is cut after the harvest of its bunch, and suckers are allowed to bear the subsequent crop. This process is repeated year after year in the rich alluvial banks of Cauvery in Tanjore district. Planting banana after banana in the same land elsewhere undoubtedly leads to a progressive decrease in the yield of succeeding crops. Banana is, therefore, generally rotated with a cereal or other crop like cotton alternately in Bombay State.

Suckers left to flower in a stool

In North India the usual practice is to remove all suckers till about 9 months after planting, when one good sucker is allowed to grow for producing the second harvest. Where leaves are marketed, more than one sucker may be left in ratoons, to follow on.

Fawcett (46) mentions that an attempt has been made

is for any economic calculation, as the receipts were realised retailing on the spot for the *Walha* variety near a large city, and not by wholesale disposal as is usual with the growers in the villages. The changed economic conditions during World War II and subsequently, make it difficult to take these figures as anything except of comparative interest. (See page 24.)

Food value of banana

Banana is accepted in all respects as a fairly nutritious fruit. It is one of the cheapest fruits and in India, the rich and poor alike are fond of it and would take it daily whenever possible. There are some varieties which are more popular in the market as dessert fruit than others. Unripe banana is a very popular vegetable in many Indian homes. It is always consumed in the cooked state but if taken uncooked, it may cause digestive disturbances. The cooked vegetable is a good source of energy being fairly rich in starch; in this respect, it resembles root vegetables like potato and sweet potato. The chemical composition of some of the local varieties is given on pages 26 and 27.

According to Brooks (20), when bananas contain 5-10% sugar content and are heated to 50° or 60°C they retain this sugar, vitamin A, B_1, B_2 complex and C and protein contents. The loss in weight is 66%, which represents a considerable saving in transport. Four drying plants are said to be in operation in the Cameroons.

The Hawaiian bananas are stated to be a poor source of calcium but a good source of phosphorus. The cooking types of bananas are reported to be a better source of vitamins than the table varieties. All bananas, however, are found to be a good source of vitamin A and C, and a fair source of vitamins B_1 and G (B_2) in their ripe stage (68). Combined with milk, ripe bananas are also recommended in Hawaii for infant feeding, and as a reducing diet for the obese (68). Sugiura (86) states that banana contains fair amounts of vitamin A, C, and B complex. In the Philippines, some varieties are given to children as they are more easily digestible than other foods. Chevalier (35) states that an excellent cider may be made from bananas as good as, if not better than good French cider, and this can be sold at a cheap rate.

Average composition of the edible flesh of fruit according to Winton (94) is as below :—

Solids Total	Solids Insol.	Protein	Acid (Malic)	Invert sugar	Sucrose	Ash Total	Ash Alk.*
%	%	%	%	%	%	%	ml.
27·54	3·40	1·16	0·41	11·69	10·37	0·86	91

*Ml. 0·1 N acid per 100 gm. fruit.

Mottram and Graham (72) analyse banana as per table given below :—

Grammes per 100 grammes				mg. per 100 grammes								Acid base balance per 100 grammes
Protein	Available carbohydrate	Unavailable carbohydrate	Calories per 100 gms.	Na.	K.	Ca.	Mg.	Fe.	Cu.	P.	Cl.	c.c $\frac{N}{10}$ Alkali
1·1	19·2	3·4	83	1·0	348	6·8	41·9	0·41	0·16	28·1	78·5	79

Vitamins—International units per 100 gms.

A	B_1	C	Remarks
250-340	30	146-300	Moderate for C

Qualitative data on different contents is given by Daniel and Munsell (37) as follows:

Food	Vit. A	Vit. B	Vit. C	Vit. D	Vit. G.	Year reported	Investigator
Banana ..	250	10-50	20	0	50	1933	Eddy
(*Musa sapientum*)	200	..	..	..	..	1933	Fraps and Treichler
	..	..	10	..	..	1922	Givens, Mc Cluggage and Van Horne

The figures represent Sherman Units per 100 grammes.

Component	*Sonkel.*	*Velchi.*	*Mutheli.*	*Rajeli.*	*Rasbali.*	*Walha.*	*Basrai.*
	%	%	%	%	%	%	%
Skin	14·00	13·00	15·82	13·99	23·00	20·30	32·55
Edible matter	86·00	87·00	84·18	56·01	77·00	79·70	67·45
Moisture	68·00	65·00	76·00	76·00	68·00	72·00	74·00
Reducing sugars	9·77	10·42	5·50	10·20	4·50	4·58	5·32
Non-reducing sugars ..	12·67	10·24	14·60	7·14	14·00	10·49	10·71
Total sugars	22·44	20·66	20·10	17·34	18·50	15·07	16·03

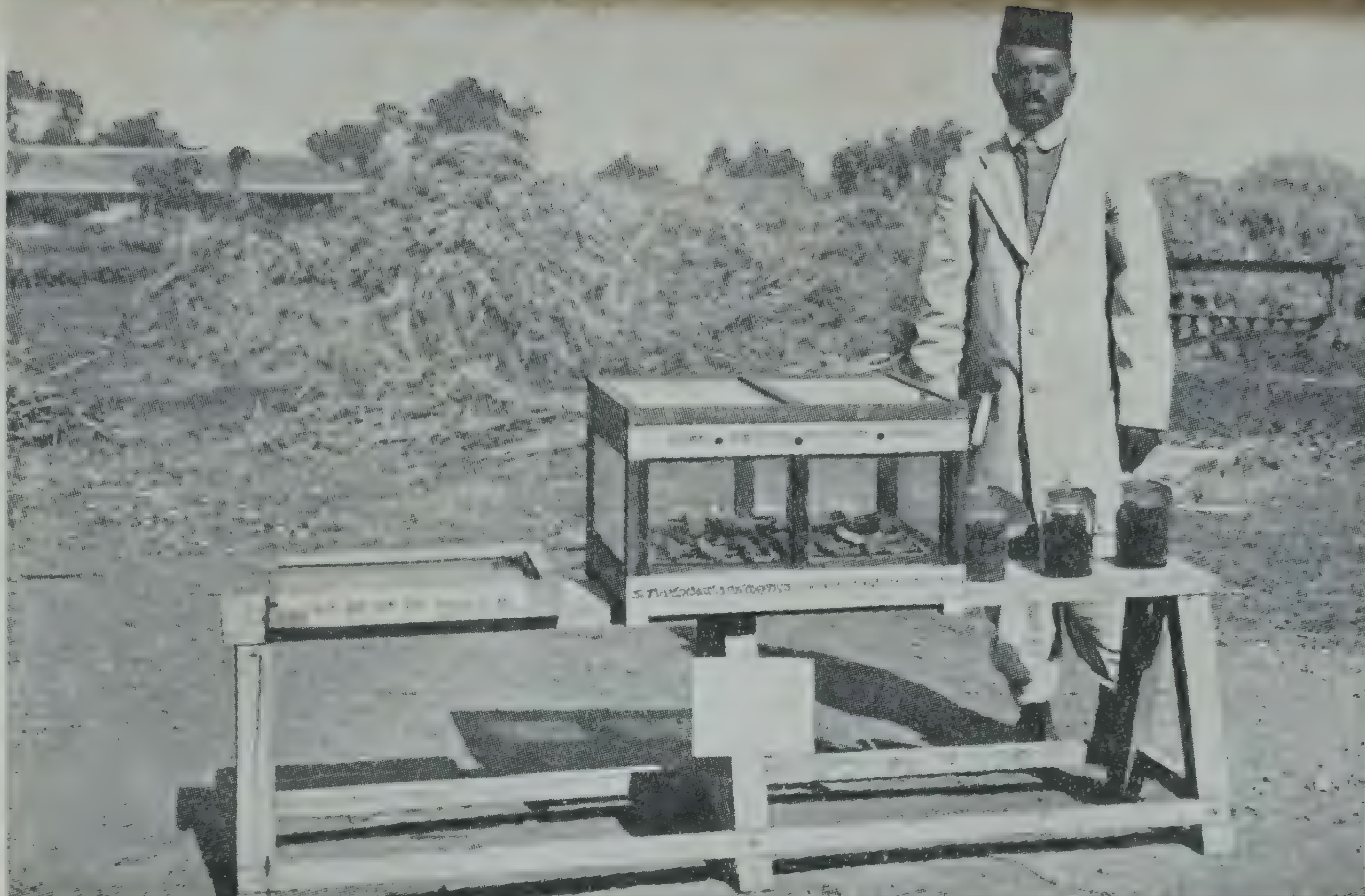
The ripe banana contains 18% to 20% of total sugars, partl as reducing sugar, and partly as saccharose. Bremond (19 describes successful experiments undertaken in Algeria i 1940 to determine satisfactory methods of making alcoho from bananas. Further experiments in 1941 in French Guinea were equally successful and factories were established, the potential output of each one of them being 10 hectolitres of motor spirit a day obtained from 120 to 150 quintals of raw material (1 quintal=100 kg.).

The fruit is used in a variety of ways. Besides the fresh fruit banana can be dried and eaten as dried "figs." It is also used in fruit salads. Green raw banana is powdered after drying and used as flour.

An excellent preserve known as *Panchamrutam* is prepared out of bananas in the Palni temple of the Madras Presidency and because of its reputation for quality there has sprung up a small trade at the place in this product. *Panchamrutam* under different local names is also a popular household dish in several banana growing areas in India.

Sun-drying

At Agashi and some other places on the Western coast of the Bombay Presidency, banana is dried for sale. It is estimated that about Rs. 5,000/- worth of dried banana finds sale in the market of the Bombay city annually. The only variety which gives an attractive dry product is the Bassein *Rajeli* as stated already. When dried, this variety assumes a beautiful yellow colour. The flesh is soft and sweet, with very little acidity. For drying well-developed fruits are plucked and stored in a heap till they are ripe and soft. The skin of *Rajeli* fruits assumes a perfectly black colour when fully ripe. At this stage, the skin of the fruit is peeled off, and the pulp is exposed to the sun. When properly dried, it assumes a golden yellow colour. The fruit takes about a week to ten days for complete drying. Low wooden platforms are prepared on which the fruit is dried. Sometimes when the drying is nearing its end, a little clarified butter (ghee) is smeared thinly on the fruit surface in order to brighten the colour. Other varieties of banana can also be dried in this manner, but the quality of the resulting product depends upon the percentage of sugar and moisture contents as well as upon the character of the variety chosen. Bananas are found to shrink to nearly



GLASS TOPPED CASE USED FOR SUN DRYING OF BANANAS IN ORDER TO SECURE HYGIENIC CONDITIONS FOR DRYING.

Facing page 28.

ne-third of their original weight when dried. Insects and flies are drawn to drying fruits in large numbers and it is always desirable to cover the fruit while drying, with cheap mesh cloth fixed like mosquito curtains about a foot over the fruits. Glass boxes are also employed in this work, where insects abound and where the hot weather is of short duration. A simple case with glass sides and glass top can be used for this purpose. The box may be provided with several ventilator holes bored into its sides. The fruit is placed inside in a single layer, and the glass case develops inside a higher degree of heat than the outside atmosphere, and the fruit is dried quicker and much better than under the curtain. The fruit is also protected in this case from dust, insects and wind. The product thus prepared is sanitary. Glass cases as described above have been tried under Indian conditions but had to be given up as uneconomical for commercial use. Dried banana has a dull colour unless subjected to sulphur fumes after peeling and before drying in the sun. Sulphur fumes also check the damage by pests on the fruits. *Rajapuri* variety can also be utilised for drying, adopting more or less the same methods as those for *Rajeli.*

Drying of bananas in the sun becomes impossible in this country for the rainy season harvest. There is no sunshine in this season often for several days due to continuous rains and cloudy weather. During summer months, the frequent dust storms make sun-drying insanitary and hence undesirable. The fruit which is kept for drying falls a prey to several insects which thrive under the peculiarly congenial climatic conditions prevailing during the monsoon season. Owing to these difficulties, artificial drying of bananas has been attempted in wooden chambers. The apparatus consisted of two main parts detachable from one another, namely, the wooden drying chamber and the fire place or the hot air generator. The wooden chambers are double fold, and rest on one side of the generator. The generator consists of a cast iron body surrounded by a galvanised iron sheet jacket, which leaves an angular space of about six inches. This jacket has an opening at the bottom through which it draws fresh cooler air of the outside atmosphere to replace the original air which gets heated and escapes through the other opening of the jacket into the drying chamber. The current of hot air is thus kept continuous and the moisture in the

fruits is evaporated as they come into contact with the hot a current. The evaporator is kept slanting and the trays can slid in it. This position helps the utilisation of all the hot air and th speed of the rising hot air current is slowed down. The smok of the fire does not enter the drying chambers and there is n risk of the fruit being discoloured and spoiled by it. Althoug the temperature of the chamber depends upon the nature o the fuel used, it is not difficult to maintain a uniform temperatur in the chamber throughout the drying period by regulating th feeding of the fuel.

A smaller type of banana dehydrator has been devised a Kodur (Madras) with a special device for maintaining a uniform temperature without having to disturb the drying chamber. A metal case is provided over the oven and this i connected to the drying chamber. The case has two small apertures on the sides which can be conveniently kept open or closed by a movable shutter for regulating the intensity of heat. Good quality "figs" have been produced from some Madras banana varieties in this dehydrator within a period of eight hours as against four to five days taken by sun-drying.

The drying chamber previously mentioned has a length of 9 feet 7 inches, a breadth of 2 feet 4 inches, inside height of 1 foot 6 inches and is kept at a gradient of 2½ ft. while working. The trays used measure 2 feet in length internally and 2 feet 2 inches externally. Their breadth is 1 foot 5 inches and 1 foot 6 inches, respectively. The trays are about 2 inches deep. In all about 22 trays can be used at a time and they can be placed in two layers. The temperature of the evaporator is best maintained at about 115°F for proper drying. A higher temperature than this causes scorching of the fruits. A temperature of 120°F for nine hours is recommended in New South Wales for preparing banana figs in dehydrators (82). If banana "coffee" is to be prepared, the temperature is raised to 130°F after the figs are prepared. After eighteen hours of drying, the figs are roasted in a coffee roaster and ground in an ordinary coffee mill. The powder thus obtained is used in proportion of two teaspoonfuls in half a pint of water to which half a pint of milk and sugar to taste

are added later. Dehydration of bananas is likely to pay in the districts of North Kanara where proper transport facilities do not exist. Mr. P. G. Joshi, former Superintendent of the Ganeshkhind Botanical Gardens, Kirkee, reports that a London broker had tried his sun-dried banana sample and remarked that he had found them better than the Philippine and Canary Island products.

In countries where the climate is dry, ripe bananas are exposed to the sun till the skin begins to wrinkle, when they are peeled. The peeled fruit is then again further dried in the sun until crystals of sugar are formed on their surface. The dried product is then packed. This process is practicable in dry climates only. Another process is to ripen the fruit and then to cut it into four lengthwise pieces, and dry them in the sun on bamboo platforms. The product develops sugar crystals on the surface and keeps for several years. A third method is to boil the fruit in water to which a little gypsum (calcium sulphate) is added, and then to dry in the sun on bamboo platforms.

Gaton (48) discusses the value of banana flour as a food and compares it with other materials. He mentions "banana pommo", "Su" and "Sung Traw" as varieties of Indo-China which yield a good quality flour. Banana flour is prepared from fully mature but unripe fruits which are peeled after loosening the skin by blanching and sliced into $\frac{3}{16}$ inch thick slices which are fed on wooden trays and then exposed to sulphur fumes in a sulphur box for half an hour. They are then either dried in the sun under dust-proof conditions as far as possible or dehydrated in the home-drier at a temperature of 160°-165°F. The dried chips are then powdered in a ball mill to form a good powder. This is used as food when mixed with cereal flour.

Diseases and pests of banana

Several important diseases and pests of this crop have been noticed in India. The important among them are the following:

1. The Panama disease caused by *Fusarium oxysporum*, var. *cubense*.
2. The banana scab. *Gloeosporium musarum*.
3. The banana weevil (*Cosmopolites sordidus*).

Panama disease

The Panama disease occurs under a variety of co tions and is of great complexity. It is a wilt disease cau by the soil pathogen named above. organism attacks the suckers and roots the plants. The name Panama disease comes from the that the disease was first recorded in Panama in the year 1 and a few years later it was found to play havoc in plantation Panama and Costa Rica.

Considerable work has been done to check the Pana disease by breeding resistant varieties in the West Indies. Gros Michel type of banana which is the chief table fruit p duced in those islands for export to North European mark was found to be very susceptible. Finding that the fun cides were not effective in controlling this disease, breeding resistant types was taken up at the Imperial College of Tropi Agriculture, Trinidad, in the year 1922. Since then good deal of work has been done on this problem, and a bana strain named I. C. I. (Imperial College No. 1), which clos resembles the Gros Michel though possessing a few very mi defects, has been evolved. The work is being continu with a view to improving the I. C. I. strain further.

The following varieties in the Philippines are reported to resistant to this disease:—

Sabe (*M. sapientum*, var. *compressa*).
Tennate or Gloria (*M. sapientum*, var. *Ternatensis*).
Bungulan (*M. sapientum* var. *suaveolens*).
Lacatan (*M. sapientum* var. *lacatan*).

Wardlaw reports that the Panama disease has been succe fully controlled in Honduras by flooding and that infect fields flooded for six months have produced fruit for nea six years with only sporadic outbreak of the disease.

Occurrence and symptoms of Panama disease and its causes

During the last few years the Panama disease also been noticed in parts of the Bombay State, *e.* at the Aley village and round ab Junnar in the Poona district. The troul is now spreading to other areas al The most susceptible variety is fou to be the best table variety locally called the *Sonkel*. The ch symptoms of Panama noticed in this tract are that, when t

plant comes to fruit the leaves begin to wither and the fruits do not develop. Leaves and suckers dry up. The fruit becomes useless if it matures at all. The disease affects the vascular tissues which become discoloured. The disease is attributed to the formation of a high subsoil water table or water-logging conditions of the soil and consequent lack of soil aeration and development of acidity in it. It also occurs in soils lacking humus. Very shallow soils appear to favour the disease. Prevention and remedial measures against this disease have not yet been worked out. The banana varieties are found to be resistant in varying degrees to this disease. A change of variety for planting, therefore, seems to be a possible step in preventing this trouble.

Preventive and remedial measures

The banana scab

This is a disease of the fruit and is caused by the fungus *Gloeosporium musarum* which develops on the fruit stalk. A reddish brown clour develops on the fruit and when closely observed, minute transverse markings are noticed. They develop into numerous longitudinal shallow cracks and turn black in colour. The skin begins to dry and turns greyish brown. The cracks grow larger and deeper. The pulp is also gradually affected, becomes dry and discoloured. Pustules on the affected skin contain spores. The remedy is to spray the bunches with Burgundy mixture (4 lb. copper sulphate, 5 lb. washing soda, 50 gallons water) before the disease is likely to appear.

Banana leaf spot is not common in India but the Bunchy Top is reported to have occurred in a few places. Removal of the affected plants and burning them is the only possible remedy.

Banana weevil

A weevil named *Cosmopolites sordidus* is seen to attack the banana rhizome in the Dharwar district and the Bassein area. The weevil spends its life in the banana rhizome but sometimes its damage may extend to the base of the stem. It is, therefore, difficult to deal with. Eggs are laid in the rhizome and dirty white grubs hatch out. The effective remedy is to remove and destroy the affected plants, and plant healthy suckers.

Very frequently the banana crop is damaged by low temperature. Being a succulent plant, the banana probably suffers from

frost more than several other plants. In the Northern a
Central Divisions of the Bombay State, frost damage
considerable when it occurs. It is, therefo
necessary to devise economic methods
prevent the loss caused by frost. Modern orchard heaters su
as those used in the United States of America and other Weste
countries are being examined here for their adaptabil
to this country. Raising of orchard temperature on nig
when frost may be expected by burning heaps of fuel wood
found to be fairly satisfactory in our plantations. Locally ma
heaters are used with advantage. It requires 125 such heat
per acre to raise the temperature by 5°F over the surround
atmospheric temperature.

Damage due to frost

In Queensland, it has been found that a bunch
banana completely enveloped in a bag affords not only m
protection from frost and cold winds, but
other advantages, in that the fruit is super
in length and circumference and uniform in developm
and flavour. Bagging also prevents loss from sun scorchi
splitting of fruit and ravages of caterpillars as well as spoiling
birds.

Bagging of bunches

The cost of the bags in the first instance is rather hi
but most of them will last for a second use, and the high
price obtained for the bunches will more than cover the
vestment.

Grading and packing of bananas in accordance w
known or accepted standards is unknown in the count
No special method of packing is practised. Whole bunc
are carted to the market loose in bullock carts where the d
tance is not far. Hands are cut a
packed in gunny bags or bamboo b
kets for transport to long distances. Wag
loads of banana bunches are thus sent
the Punjab and other northern parts of India from Decc
Whole bunches are wrapped in banana leaves and stowed
board the steamer for export to Basra and other places. St
dardization of the methods of grading and packing this frui
now largely practised in other countries growing banana, su
as New South Wales and Cuba. Absence of standards of gr
ing and packing gives rise to a number of malpractices a

Packing and grading of bananas for the market

adoption of standard methods of grading and packing would therefore be of great advantage.

It is essential to harvest the bunches at the proper stage of ripeness. The bunches should not be exposed to the sun as far as possible. The hands are separated from the main stem about twelve hours before packing. As much of the stem as possible is retained with the fingers lest the stem-ends blacken and the fruit loses flavour. For long shipments, boxes are found to be more suitable than bamboo baskets. Hangers will be better if they can be provided. In packing the fruit, the bunches are cut into three or four pieces and their inter-spaces are filled with single fruits. In grading, a high standard should be maintained and different sizes of fruits should be strictly packed and sold under different grades. Bananas exported from the Madras Presidency are booked in railway wagons without any packing, or with only a lining of banana leaves between every two layers of fruits.

Farringer (45) concluding his note on the outlook for the banana industry in the American tropics suggests that air transport may be instrumental in introducing some of the more delicate and perishable exotic varieties to north American consumers.

Clean bunches of banana are carried in special holds from the West Indies to the British Isles. In the Canary Islands the fruit is packed in crates made of the following pieces:

16 side pieces, each $\frac{5}{8}$″ thick, $2\frac{1}{2}$″ broad, and 26, 28, 30, 32, 34 or 36″ long.
6 end pieces, each $\frac{1}{4}$″ thick, $2\frac{1}{2}$″ broad and 14″ long.
4 head pieces, each $\frac{5}{8}$″ thick, 22-27″ long and $2\frac{1}{2}$″ broad.
4 head pieces, each $\frac{5}{8}$″ thick, 12-17″ long and $2\frac{1}{2}$″ broad.

30 pieces in all per crate.

The Cavendish variety of banana which is the chief type grown in the Canary Islands has soft skin and, therefore, requires crates of the above description for packing for safe transport. The bunches are generally laid in with the stalk, while packing in the crates. High quality bunches are wrapped in cotton wool sheets before packing.

Maize husk is also often used for packing fruits for shipm The insulating and absorbing qualities of this packing m rial together with efficient ventilation of the fruit du shipment assure safer conditions of transport than those of storage. Eastwood (44) advocates packing in hands or clus instead of the prevailing method of packing in singles in N South Wales. In the Gold Coast tract the Canary type banana is packed with paper bags round the bunches (2 This system is found very convenient and economi Bunches are harvested within twenty-four hours before shipme Cut stalks are smeared with vaseline on trimming before sh ment. Gregory (50) of Queensland recommends that the lowing instructions may be carefully followed while handl fruits for packing:—

1. Select only mature fruits.
2. Avoid bending of the shanks of bananas when rem ing the bunch from the plant and transporting to the packing house.
3. Keep bunches in a vertical position.
4. Pack in good case of timber with thick sides to maximum protection in transit.
5. Keep fruit cold during summer when harvesting a transporting. In winter keep the fruit from bei chilled by protecting it from cold winds.
6. Clean fruit of all foreign and decayed matter.

The banana packing case should be made of good timb free from knots. The end should be $\frac{3}{4}''$ thick and where cle are used these should be 2″ wide and $\frac{3}{8}''$ thick.

In Queensland the bananas are graded into sixes, seve eights, etc., according to the length and thickness of the fru Sweating before packing is also practised in some cou tries. The fruits are stored for 24-30 hours before packi This helps them to keep long and stand transport better. Wh packing, fruits are packed in layers and different methods su as "single pack", "single alternate pack", "vertical two pack etc., are adopted. Of these methods, the "full hand pack" a the "part hand pack" are considered the best.

In transporting the fruit to longer distances, it is advisable to select only well developed green bunches, because ripe fruits decay and a great loss might occur subsequently. For long distances, fruit is packed raw and ripened artificially.

Artificial ripening of banana fruits

Banana is ripened in some countries by the aid of gas heaters, the bunches being staked in specially constructed rooms. As some accelerating agent is necessary to ripen the fruit successfully, it is thought that this is provided by the ethylene gas. It is recommended that coal gas be used instead, a concentration of one part per thousand having been found sufficient in reasonably air tight rooms in the summer. The optimum conditions for ripening bunches are 68°F temperature, and 85% humidity to the "spring stage" followed by 70%, and in winter 85% to the "colour show" stage followed by 70%. Temperature of 75°F to 80°F for ripening the banana in air tight chambers is good. The period taken for ripening varies from six to forty-eight hours. In the Canary Islands the green fruit is exported just when it requires about 20 days to ripen. The bunches for export comprise eight hands in the minimum. Smaller bunches are said to be useless for export.

At some places in the Deccan (Bombay State), banana hands are heaped one over the other, covered with straw and mud and then smoke is blown into the heap. The green fruits change their colour due to high temperature thus generated. Ordinarily, atmospheric temperature in Western India is fairly high throughout the year, and therefore, it is not considered necessary to adopt artificial ripening processes for this fruit in this region. The most favourable temperature for successful ripening was found by Chona (36) to be 15°C to 20°C. The temperature in the curing pit during the summer months in the Punjab ranged from 35°C to 40°C. The pits provide no check on the growth of various disease organisms. By practical experience it has been found that banana and oranges cannot profitably be sent in the same hold. Emanations given out from oranges effect premature ripening of bananas and, therefore, it is necessary to have separate storage for citrus fruits and bananas.

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CHAPTER II

MANGO

(*Mangifera indica L.*)

"It will be hard to think of a fruit which has appealed to the people of this country to a greater measure than the mango. From the point of view of acreage and production, mango is easily the most outstanding of all Indian fruits. The adaptability of this fruit to a very wide range of climatic and soil conditions, the relatively hardy nature of the tree, the low cost of its culture and maintenance, and above all, its healthful dietetic qualities and its universal popularity as one of the choicest of the table fruits have contributed to accord the premier place to the mango practically in every nook and corner of this country" (98).

The United Provinces is the leading mango producing region of India, and produces about 3,300,000 tons of mangoes annually from an area of about 1,322,656 acres. The rapid extension of acreage under mango in the Bombay Presidency from 10,455 acres in the year 1920 to 27,701 acres in 1947 is a strong evidence in support of the fact that this fruit is increasingly catching the imagination of the progressive cultivator. The efforts to explore European markets for the Alphonso fruits made in the early thirties stimulated interest in this fruit and have encouraged growers and traders to invest capital in it. New area is being planted and new methods of packing and marketing the fruits are being tried.

Mango is at present one of the most important fruit crops in the Bombay Presidency. The total acreage under this crop is the highest, save banana. This area is spread in two chief tracts, namely, all along the western coast touching the Arabian Sea from the North Kanara district in the South to the Gujerat districts in the North, and in the Malnad and transition tracts extending from Dharwar to the Nasik district. The area under mango in other districts is comparatively small and scattered. From these facts it will be seen that mango production is a fairly large sized industry in this Presidency. The coastal tract com-

monly known as Konkan is renowned for mangoes of a qualit equal if not superior to any produced in any other countr in the world. The soil and climate of this tract are ex tremely well suited to the cultivation of mango. Mangoes fro this area have naturally established their own reputation an command a distinct premium in the markets of some parts o India and abroad. Other parts of the Presidency do produc considerable mango crop, but the fruit is mostly meant for loca markets.

History

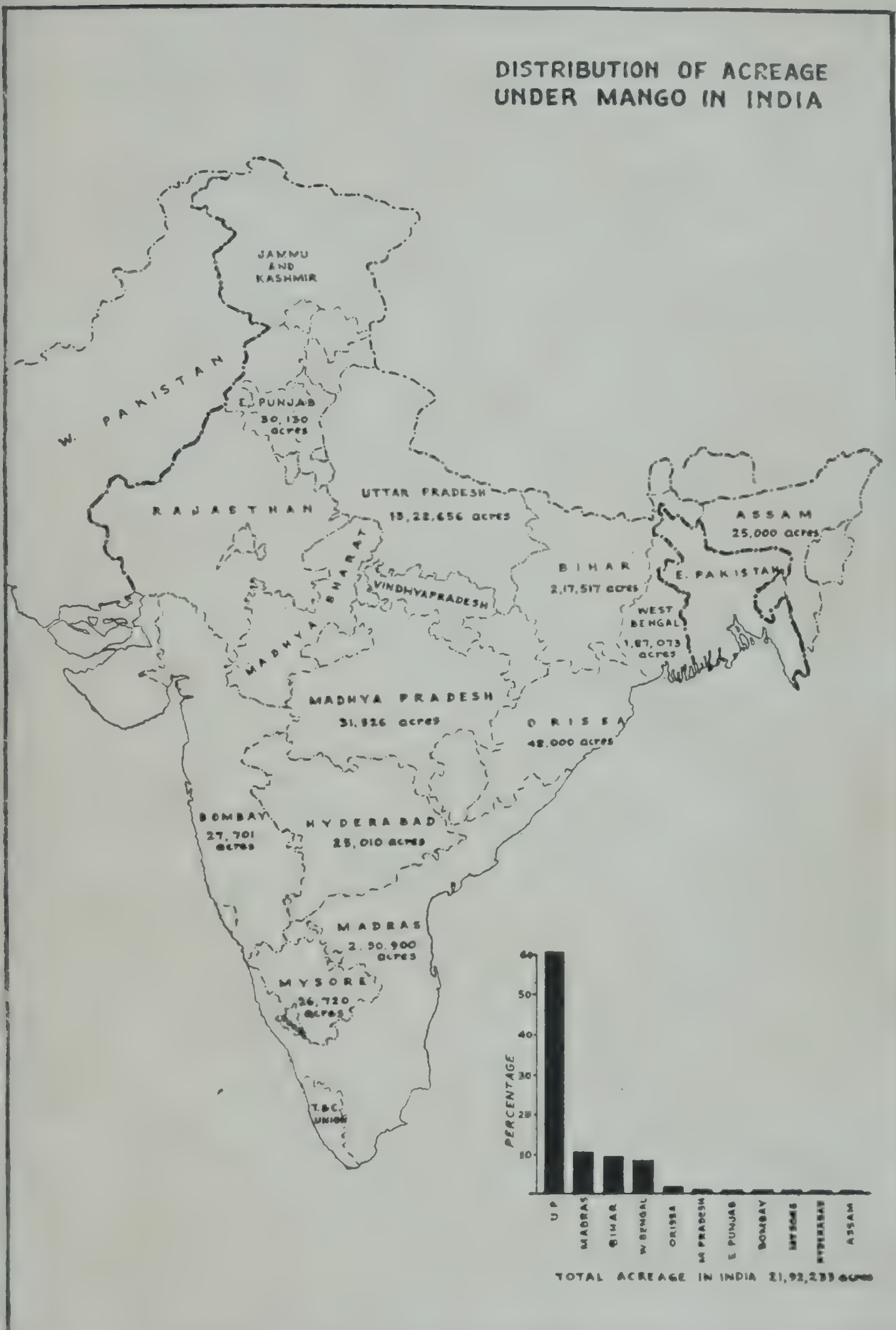
The mango is now grown in almost all the tropical and sub tropical climates. Its original home is believed to be some where in Eastern India and Malayan Archi pelago. Its numerous varieties have s early—indeed prehistorically—disseminated to other parts o India, that it is found difficult to trace the origin of mang to a more restricted region. From the evidence so far avail able it would appear that the monoembryonic mango ha probably originated in some parts of India, but the polyembryo nic types or races have their origin somewhere in Malaya.

Regarding the age-long appreciation of mango, it is enough to record here, the innumerable references to the diaries of tra vellers from the Chinese Hiowan-Thsang (632 A.D.) to Pirar who travelled in India in the early parts of the seventeenth cen tury. A good deal of prominence is given to this fruit an consequently to the tree and its leaves in Indian religious cere monies. Further, several hundred horticultural varieties o varied descriptions and local importance existing in all part of India go to prove the remote antiquity of this fruit in thi country. Huge seedling mango trees, a hundred to two hundred years old are not uncommon in almost all parts of India.

In India the chief mango provinces are :

MANGO ACREAGE

U. P.	1,322,656	acres	E. Punjab	30,130	acres
Madras	250,900	,,	Bombay	27,701	,,
Bihar	217,517	,,	Mysore	26,720	,,
W. Bengal	187,073	,,	Hyderabad (Dn.)	25,010	,,
Orissa	48,000	,,	Assam	25,000	,,
Madhya Pradesh	31,526	,,	Total	2,192,233	acres



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The total area under mango in this country is 21,92,308 acres (1947-48). The area at present planted to mango has been the result of spontaneous effort of the appreciating grower and has by no means reached its limits. It would appear, therefore, that there exists a very wide scope for the expansion of mango cultivation and subsequent development of the mango industry in this vast country, provided the educated public realise its commercial possibilities and the activities of the various Agricultural Departments are properly directed. The existence of a large number of seedling trees of varied description and quality and grafted varieties of mango with numerous highly appreciated types will only assist such expansion.

Distribution

"The present confusion in classification as to groups and varieties of mango is so great that although considerable interest is being shown in the work, a long period will be required before a satisfactory adjustment is reached." So said Kinmen (79) of the Porto Rico Agricultural Experiment Station in 1918. These remarks are perhaps as true today as they were over three decades ago. Several sporadic and abortive attempts have been made to group together available varieties of mango in all mango growing parts of the world, but nothing tangible seems to have been yet evolved. The large number of varied seedling types, the multiplicity of soil and climatic conditions under which they grow, the innumerable regional names and synonyms prevailing for the varieties; the wide variations in their fruiting seasons and the long distances that divide the mango growing regions of the world make it almost impossible to collect together at one place and time all or even a large majority of the so called mango varieties for purposes of accurate description, proper comparison and correct classification. The few attempts made towards this end are neither exhaustive nor comprehensive enough to be linked together. As one of the best fruits on the surface of the globe, the mango ought to have received long ago a much more serious attention and strenuous effort of the systematic pomologist than it has hitherto done. It is hoped that it will not be long before this fruit is classified on natural lines and standard varieties are established.

In this connection it is gratifying to observe that the Indian

Council of Agricultural Research is devoting attention to evolvi a system to classify the large number of Indian mango varieti by proper description supported by charts and true to colo drawings. A monograph on "Classification and Nomencl ture of South Indian Mangoes" has been published recently b the Madras Department of Agriculture (Supdt., Govt. Pres Madras, 1950). Valuable material has also been collected o this subject at Baroda and elsewhere, and nation-wide endeavo to collate and codify these is necessary.

The erstwhile method of designating varieties solely o the basis of fruit description collected mostly from one localit has been replaced by a more rational description of all essenti parts of the tree under diverse conditions of growth. Thes investigations have brought to light, that the fruit forms but on of the vast number of indices for identification of varieties; an this leads to the hope that evolution of a practical key for natur classification of our horticultural varieties of mangoes based o a number of important vegetative and fruit characteristic during the various stages of the growth of the plant i within the realm of possibility. One such key has bee suggested by Naik and Gangolly for south Indian mangoes i the monograph referred to above.

Varieties of mango which are well known and valued in various parts of India are many. They are named after great men, seasons in which they ripen, colour, flavour, and various other factors. These names are often synonyms. Some of the varieties have local importance while others are known to the trade. Some of the important varieties of India are given below:—

Punjab	*Langra*, and seedling types.
Western United Provinces	Bombay (green and yellow), *Fazli* and *Langra*.
Central United Provinces	*Safeda*, *Dasheri*, *Khasulkhas*, *Samarbehist* and *Langra*.
Eastern United Provinces and Bihar	*Langra*, *Zardalu*, *Fazli*, *Gulab Khas*, *Bombay* (green and yellow).
Bengal	*Malda*, *Shadivala*, *Pulihora* and seedling types.

Bombay and Goa	*Alphonso*, *Mankurad*, *Fernandin*, *Maldez*, *Bishop*, *Musherad* and *Mulgoa*.
Northern Circars	*Jehangir*, *Himayuddin*, *Banganapalli*, *Chinna Suvarnarekha* and juicy varieties.
West Coast	*Olour*, *Mundappa*, *Neelum*, *Alphonso* and *Pairi*.
Central Madras	*Neelum*, *Bangalora*, *Baneshan*, *Rumani*, *Mulgoa* and *Alampur Baneshan*.
Southern Madras including Salem	*Neelum*, *Alphonso*, *Pairi* and seedling off-season bearing types.
Mysore	*Badami*, *Raspuri* and *Totapuri*.
Baroda	*Alphonso*, *Rajapuri*, *Jamadar*, *Salebhoy*, *Amdi* and *Vanraj*.

In the Presidency of Bombay, the Alphonso and Pairi are the most popular varieties of commercial importance. Due to its superior taste, colour, medium size and keeping quality, the Alphonso which is considered to be the best Indian mango, has spread under cultivation in various parts of India like Madras and the Hyderabad regions also. Other varieties such as the *Batli*, *Shendrya* and *Kala Ishad* are also well-known. The *Cowasji Patel*, *Khus*, *Amin* and others are fruits of large size with pulp of good texture, mostly used for pickles and preserves.

Soil

Mango trees are seen to grow well in a variety of soils from the well drained laterite soils of Ratnagiri, Goa and Belgaum and the medium black soils of Thana, Surat, Poona and Satara to the heavy deep black soils of the Sholapur and Bijapur districts. That the mango is among the least fastidious of fruit trees regarding soil conditions is further evinced from the fact that luxuriant plantations are to be found in the fertile Indo-Gangetic alluvial loams of the United Provinces, Bihar and Bengal, the Deltaic paddy lands of the north-eastern part of India, and the poor, rocky, light loamy soils of the hilly and lower mountainous region. There are huge old mango trees near Nasik and Khed Shivapur in the Poona district growing in medium black soils. Trees growing in the heavier soils of the eastern districts are not so large, nor do they stand comparison with the sky-scraping wide spread trees

of the Western Ghats. While moisture in the soil and humidity in the atmosphere promote the healthy vegetative growth as well as fruiting of mango trees in any kind of soil, a well drained fairly deep loamy soil is generally conducive to their best performance. The fruit borne by trees standing in sandy soil is reported to be "decidedly of inferior quality, watery and insipid" (92). Soils with a hard substratum or marl are also not good as they hinder the proper penetration and development of roots.

Temperature

Being essentially tropical, the mango tree cannot stand severe cold and frost conditions. A hot period is necessary for the development of the fruit. Mango blossoms generally appear during December to March, and any frost occurring during this period, as it often does, in sub-tropical and temperate regions, proves disastrous to the mango crop. The young plants and tender shoots and inflorescences of larger trees are killed by frost. In such tracts, however, "imported plants of mango seem to suffer most from cold than those raised from seeds in the country" (25). Although certain varieties seem to be more resistant to frost than others, stronger and healthier plants, in general, resist frost more than the weaker ones.

Rainfall

Rainfall during the blossoming season is highly detrimental to the crop. Rains injure the stigma, wash the pollen away and cause it to remain damp. Rains also develop conditions which encourage the powdery mildew and other diseases. The mechanical injury to the unprotected pistil is great. Much harm is caused to the mango crop even by prolonged cloudy weather during the flowering and fruit-setting period, as it encourages the flower-destroying fungus and the jassid hoppers. In tracts where late anti-monsoon rains damage the mango blossom, as in the Eastern districts of the Bombay Presidency, low yields and crop failure are perhaps much more common than in the Konkan and the transition tracts, where a dry period prevails at the time. Not only rains, but even excessive dew is apt to wash away the pollen grains depriving the pistils of their chance to be fertilized. Gunaratnum (61) observes that in Ceylon mango can grow in the dry zone with little or no irrigation with a rainfall of 25 to 75 inches

PREPARATION OF CHARCOAL BY FELLING OLD SEEDLING MANGO TREES OF INFERIOR MANGO VARIETIES

per annum and on lands from 300 feet below sea level to 1000 feet above sea level.

In tracts subject to heavy precipitation as the West coast of India, some damage is also caused by early rains to mature fruits, and as a result it is found that the growing of the late varieties is a very precarious venture. Even in other areas, unexpected heavy showers may cause enormous fruit drops and serious loss to the growers.

A fairly high percentage of moisture in the soil is essential for the well-being of the mango tree, because in general practice it is not irrigated, but depends upon natural precipitation after it comes to bearing. Economically, therefore, the mango thrives best in regions where the annual rainfall is above thirty inches and even up to one hundred and fifty inches or more, provided there is no rainfall during the flowering and fruiting season. These conditions prevail in the Western parts of the Bombay Presidency, where mango thrives to its best. In drier tracts, however, the mango tree does well with irrigation. In the Madras Presidency, although the rains occur for a much longer period than in Bombay, they do not cause any damage to the mango trees, as the rains do not occur during the flowering and fruiting periods.

Altitude

Although the mango tree can grow from the sea coast upto a height of about 4,000 feet, it crops well only up to a height of about 2,000 feet if other conditions are favourable. Fernandez (46) states that any climate in Brazil in which the temperature does not fall below 0°C will suit mangoes. It is at its best in well drained, alluvial soils and in cool, sandy clay soils rich in humus and this especially refers to fruit quality.

Variations in seedlings

In raising a mango plantation, the rootstock may play an important part. Under natural conditions, the mango multiplies itself by seeds. In some parts of India, certain well-known varieties of mango are propagated by seed even now. It is not generally realised that seedlings of monoembryonic mangoes do not come true to type. Popenoe (122) writing about the mangoes of Cuba and obviously referring to polyembryonic mangoes observes: "It has long been recognised in certain parts of the Tropics that many seedling mangoes come more or less true

TECHNOLOGICAL RESE

to type, when propagated from seeds and because of this fact the natives have learnt to recognise certain of the best defined types and have distinguished them with varietal names." He adds further that "We must admit the possibility for the time being that occasionally it may depart from the type perhaps because of cross pollination, perhaps because of some other cause." On the phenomenon of polyembryony, Popenoe quotes Belling of the Florida Experiment Station (1908), "the embryos arose as minute vegetative buds in the nuclear tissue surrounding the egg shell." Webber (186) from an examination of the Peach mango in the Transvaal considers that the degree of apogamy is about 100 per cent. and that the testing of the degree of apogamy in valuable mango varieties would be worthwhile before resorting to vegetative propagation, as seedling propagation is cheaper. Wester (189) remarks that the types of mangoes grown in the Philippines are all polyembryonic and therefore reproduce their special characteristics to a remarkable degree. He also states that the progeny of the monoembryonic types of India is variable. Horn (71) mentions that polyembryony in mangoes was studied in Porto Rico also.

Till recently all the Indian varieties of mango were considered as monoembryonic and hence, as a rule, they were thought not to come true to type. Recently about a dozen polyembryonic varieties of mango have been isolated in the region on the West coast of India by one of the authors, and as many as five seedlings per seed have been obtained and successfully planted. Over 30,000 acres under mangoes in Malabar and parts of South Kanara districts are planted to seedling mangoes. Since the trees are known to reproduce the parental characters to a high degree in these parts, it is inferred that this character is due to polyembryony. Some of the isolated varieties are reputed to bear fruits three to four years after sowing and have been found to reproduce the parental characters completely like all of other propagated trees.

Hartless (64) affirms that the mango is predominantly anemophilous. Burns and Prayag (25) record their observations that the mango flower is entomophilous and designed for short tongued insect visitors. Popenoe (123) also considers it as "truly entomophilous" and in discussing the

haracters of the mango flowers, he remarks that it is entitled to e placed in Muller's biological class A, or flowers with freely xposed honey.

While self-pollination in mangoes is recorded as possible, he transfer of pollen to the stigma does not seem to be accomlished easily without the intervention of an external agency in pite of the close proximity of the organs. "Both the stamen nd the pistil retain an erect position throughout and the pollen, s it is shed, usually falls upon the base of the ovary or the disc ather than upon the stigma"(25).

Wide variations in the nature of the fruits produced as well s in the vegetative characters of the seedling trees are recorded s a result of an experiment carried out at the Ganeshkhind ruit Experiment Station, Kirkee and the Modibag garen, Poona during the course of over a decade for the urpose of collecting data as to whether mango seedlings come ue to type or not. In this experiment, seedlings were ised from stones collected from the same individual parent ees and were allowed to bear fruit under uniform condiions. It was noticed that the vegetative habits of these seedng trees varied to some degree, but the fruit characters dislayed wide differences in the size, shape, flavour and constency of pulp, stringiness, etc. It is thus established beyond oubt that mango seedlings of the monoembryonic group vary om the parent tree both in vegetative as well as in reproducve characters.

Despite the variation in seedlings, it must be admitted that odern mango growing industry owes a great deal to seed proigation for the production of the choicest of our present day llection of grafted mango varieties. The origin of all the esent commercial varieties of mango has been invariably due chance occurrence of seedling trees in nature. When the gh quality of the fruits of these seedling trees became known, ango enthusiasts took grafts from such trees, and thus the oriial individual was multiplied vegetatively until it attained a ognised status of a commercial variety. This is how the nous Alphonso, *Langra*, *Pairi*, and other varieties have ead under cultivation for more than a century. The *Samarist Chaunsa* of the United Provinces, the *Chinna Suvarnaha*, *Jehangir* and *Himayuddin* of the Northern Circars and

Mundappa of the Malabar coast as well as the *Rajapuri* c Gujerat and the *Jamadar* and *Salebhoy Amdi* of Saurastra, ar some of the varieties which have become most popular in thei respective tracts during the last two or three decades, havin been originally propagated from single individual seedling trees The original seedling trees of *Chinna Suvarnarekha* and *Mundapp* are alive to this day and serve as a source of great interest t thousands of growers who cultivate these varieties. Similar i the case of the *Borsha* mango of Khandesh in the Bombay Pre sidency, the original *Borsha* tree which is over three hundre years of age, being alive in huge dimensions to this date.

Vegetative methods of propagation

Asexual methods of propagation are, however, necessar in the case of commercial culture of most mangoes. Althoug several workers report to have found it possible to propagat mangoes from cuttings, layering and gooty (marcotte), th method adopted in general practice i India for the propagation of superio varieties of mango is grafting on seedlin rootstocks by the simple approach method and is known a enarching. Recently a number of workers have pointed ou that cuttings of woody plants, if treated with growth-promotin substances strike roots readily. Girdling the shoots is als known to promote root growth and a few mango plants hav been successfully raised from girdled shoots at the Kodur frui research station, Madras. Cooper (33) has pointed ou that some root forming substance in the plant is transporte downward in the phloem and impeded by the girdling opera tion. If the girdled shoots are treated with heteroauxin solu tion, the number of roots per shoot is increased. H suggests that the heteroauxin accelerates the downward move ment of a substance called Rhizocaline, which is necessar to root formation. The use of seedling rootstock, however is found to be more economic and profitable than the us of cuttings on account of the long time taken by cutting to strike roots, the low percentage of success and the weak roo system formed by this asexual method.

Rolf's (146) remarks in this connection are worth noting He observes that "if one has thoroughly ripened healthy mang wood, it is possible to strike cuttings with the help of ordinar green house appliances. The cuttings are made in the usua

;ay and struck in the ordinary bench, with bottom heat. If harp sand is employed in the bench, the cuttings should be emoved to pots when they have struck roots." Discussing he advantages of making rings on mature branches prior to reparing the cuttings, he adds "many of the cuttings made in his way struck readily enough, but the root system was weak. On this account, this method is less desirable for propagation han the use of seedling stock." Burns and Prayag (25) state hat they could not make cuttings strike roots. They were uccessful in having some plants by layering and marcotte, but hey do not recommend these methods to be preferred to grafting, owing to the difficulties mentioned above. Budding is done when the rootstock is in active growth, exhibited by the emergence of new flush of leaves. In Florida the operation is done normally in May or June while the months June, July and August have proved successful in most parts of India.

The method of grafting most commonly adopted here is enarching (or inarching), because of the simplicity of the operation, the ease with which it can be carried out, and the high percentage of success attained. Side grafting is practised in humid climates with considerable success. Other methods uch as tongue-grafting are less frequently adopted under divergent circumstances with some success in different tracts. Cleft-grafting is now being employed on some scale in Ceylon on young and about three month old rootstocks. Budding of mango has been done with success at Poona, Madras and in he Punjab adopting the modified Forkert method, but it is not yet adopted by nurserymen as a commercial practice as in Ceylon. For enarching, seedling rootstocks are first raised in pots of suitable size. The pots employed in the Bombay Presidency are generally conical, 8-10 inches or more high and about 6 inches n diameter at the top. The base is narrow. These pots are pecially prepared for nursery use only. They have the advantage of permitting the removal of the plant raised in them without breaking the ball of earth and without disturbing the roots while transplanting later on. The pots are not generally used more than once. Round pots called *madkis*, are also used. The conical pots are called *kundis*. *Madkis* are cheaper in price, help the soil to retain moisture and remain cool for a longer time than the *kundis*. Both are types of rough earthen pots. These

pots should be well baked in the potter's furnace before use wh is identified by the metallic sound produced when they tapped. If the pots are not baked well, they break easily.

A few nurserymen in the South Kanara district prep containers made of hill grass twists, knit together into form of a pot. Such grass containers, besides being cheap a light, afford no room for root injury at the time of potting. Ceylon and the West coast of India, bamboo pots cut i a suitable size with drainage holes as in earthen pots, are a used at times. Bamboo baskets, that are so popular w coffee planters in South India are used occasionally for raisi mango seedlings.

Compost for filling pots

When the pot is selected, a small hole about one in in diameter is bored at its bottom. This hole permits f drainage. It is protected from being chok with soil by placing a few pieces of p sherds with their concave sides facing (48). On them are put a few dry leaves, coir or rags as further measure of drainage protection. These dry leaves, c or rags are not meant to serve the purpose of manure or supply nutrients to the pot plants. When the pot is thus read it is filled with a mixture of the following composition:

> Two parts of alluvium or ordinary surface soil, o part of sand or brick powder and two parts of le mould
>
> or
>
> Eight parts of leaf mould, eight parts of red earth ar one part of sand.

Various other formulæ are also being adopted for preparin a good pot mixture. Whichever mixture is used, the underlyin principle seems to be to have a medium of loose composition, that there is as little risk as possible of breaking the tender roo of the seedlings in the process of what is called pricking ou This compost should also be rich enough to provide adequa nutrients to the young plants in the limited space.

Generally, where a large number of pots is prepared eve year for sowing mango stones, a free supply of alluvial soil, le mould and sand is stocked in advance of the sowing season. Th sand and leaf mould are properly sieved to remove the larg

›ieces which do not give a uniform consistency to the mixture. They are mixed as required for use during the season. Filling of the pots with mixture is done upto about an inch from the rim. This space in the pots is essential in order to hold water. It is not necessary to provide holes for drainage when baskets are used.

Sowing of mango stones

Sowing of mango stones (mango seeds are popularly called tones on account of their hard seed-coat) then follows. It is ound highly desirable to select good stones for this purpose. Stones should be fresh for satisfactory germination. They retain their viability under ordinary conditions for a few weeks only. In India tones of country or seedling types, which are prolific bearers, re preferred to those of superior table varieties for raising roottocks. They should be plump, well developed and healthy. For his purpose, fruits are left to remain on the trees for a long time intil they are fully ripe. They are then harvested and allowed o rot. The stones are then extracted. They are further graded ind the heavier ones are generally used for sowing. Heavier tones are commonly believed to produce more vigorous and tronger seedlings than lighter ones. Two or three selected tones are sown in each pot, not more than an inch deep. Sowing s done nearer the side of the pot than in the centre. The soil s well pressed and copiously irrigated after sowing is done. In everal parts of India, particularly in the South, mango stones re sown in well prepared nursery beds. If care is taken to ift the seedlings when they are not over about eight months of ige with a ball of earth round the roots, and to pot them in a eason when atmospheric humidity is high, the casualties are egligible. In Gujerat mango seedlings raised in nursery beds re potted when they are a year old. Their long tap roots are ut back suitably while potting, which is done in the rainy season. he cheapness of the method of growing seedlings in beds as well s the more vigorous growth made in the beds than in the pots, re responsible for the wide popularity which this practice enjoys mong nurserymen. In some parts of Bihar, the stones are umped together in a heap with a thin layer of soil thrown over nem. During the monsoon, the stones germinate and as a result f overcrowding, though the seedlings grow to a considerable ize, they get very weak and appear unhealthy. These seedlings re potted carefully, one or two months after germination.

The successful transplantation of seedlings depends upon th kind of tap root produced by the plant in the seed-bed. If th growing root meets with impediments, it changes its cours producing ultimately a very crooked root. To encourage straight tap root, it is essential that the seed bed is prepare with great care and is rendered free from any hard clod of soil o other extraneous matter. It has also been found experimentall that sowing of stones with plumule up leads to the develop ment of a straighter stem and tap root than the commo practice of sowing the stones flat. Sowing of shelled stone a practice recommended in Malaya, Philippines, Ceylor Hawaii and North America has not proved satisfactory i this country. It may have a value only where due to wide spread weevil infestation, careful sorting out of sound seed afte shelling, becomes necessary.

Self-sown seedlings of mango are also often collected and trans planted in pots for rootstock purposes. As the mango seedlin is sensitive to root disturbances, many of them may die unde careless handling. In Hawaii, seed selection is done from fruits obtained in the mid-fruiting season.

Mango stone may germinate in about a month from sowing As most of the Indian varieties are monoembryonic, each ston gives rise to a single seedling. If more than one shoot is seen to come up from the same stone from such types, it may be inferred that they are all branches springing from below the soil surface They all have a single root system. In about two months when the foliage of the tender seedlings turns green, all the weaker shoots should be clipped off and weaker seedlings rogued out, and only one strong seedling left to grow in the pot.

Manuring and stirring of soil in pots

The pots with seedlings are all kept in rows in particularly shady places to enable them to grow well. If kept in full exposure to the sun, the seedlings become stunted and take a long time to gain height. Once a fortnight or so, the soil in the pots is usually stirred and a small quantity of liquid manure is added to it The liquid manure may be prepared as follows :—

1. Dissolve a handful of sulphate of ammonia in a bucket (about $2\frac{1}{2}$ gallons) of water

or

2. Mix one part of cattle urine with three parts of water

or

3. Mix one part of cow-dung (fresh) with four to eight parts of water, and remove all fibrous matter by straining the mixture through a piece of cloth or otherwise.

bout half-a-pound of any of the above solutions will be enough r each pot per application, which may be done a day after the il is stirred. The addition of liquid manure coupled with irring of the soil frequently will enable the seedlings to shoot p into active growth very quickly. These treatments also elp to maintain vigour throughout the life of the seedlings pots.

The pots are kept in long shallow trenches with dry leaves read below as well as in between the pots. The trenches are ot more than about eight inches deep. In order to economise e cost of watering, ample water is let into these trenches once eight days. The pots and the soil inside them absorb water freely to keep them supplied until the next watering turn. The dry leaves put below and round the pots help them to keep moist with this arrangement, e stock plants are seen to grow very satisfactorily. Thousands f stock plants can be thus raised with ease and economy. Iand watering of pot plants is laborious and costly. Pouring ater from above splashes out some of the soil contained in the ot at each turn of watering. Plants have also to be watered aily as they do not get a copious supply on any day. If and watering has to be resorted to for any reason, the pots quire to be filled with fresh soil or compost every month if t more frequently, lest the roots get exposed and the soil in e pots gets removed gradually. The plants in such condition not grow fast and vigorously, and make poor stock plants.

atering

Stock seedlings have to be occasionally pruned to remove all le shoots, which may sprout from terminal and lateral buds each flush. If left to grow, these sprouts rob the plant food the main shoot, which consequently becomes weak and dwarf. he pots in which stocks are being raised have also to be lifted up and placed in different spots once in about two months or so. Otherwise, the ng tap roots which have a tendency to go deep into the soil, merge from the pots through the drainage holes at their

urther care

bottom and enter the other soil. If left undisturbed, they g deep into it and when it is time to lift the pots for grafting th stocks, it is difficult to take them out without tearing the roo roughly. In consequence, the stocks raised with so much ca and trouble may be lost. It is, therefore, advisable to preve the roots from entering the ground by lifting and replacing th pots occasionally. This operation can be easily done by havin an alternate plot close by, where they can be shifted to.

With proper care and treatment, the stock plants get read for grafting in twelve to fifteen months, when they attain

Grafting

thickness of a lead pencil or about one cent metre in diameter at the height of six eight inches from the soil. Commercial nurserymen use muc older and thicker rootstocks for grafting. They use larg scions and produce big grafted plants for sale, which is profitab to them. It has, however, been shown in Bihar and Kodu (Madras) that grafting is very successful even on seedlings three to twelve months of age. Grafts on very young roo stocks have to be kept for a long time in the nursery to enab them to attain a proper size to be planted out on the orchar site. Observations made at Kodur (Madras) on seedling raised from different parent trees have indicated that th progeny of different parents differ markedly in vigour and i their rate of growth in nursery beds. This shows the possibilit of cutting down appreciably the period from the seed to th grafting stage by selection of suitable seed parents especially i polyembryonic mangoes. The young mango seedling rootstoc require to be handled with care.

Seedlings which are healthy and vigorous are taken to th scion tree for grafting by the enarch method. Enarching or graf ing by simple approach consists of joining together a seedlin rootstock and scion of equal thickness and age, by exposing the cambium layers and tying them together for a fairly long tim and then heading off the rootstock after detaching the graft fro its parent tree. The actual operation commences with th selection of a scion shoot of equal age and thickness from desirable parent for every seedling rootstock in pot. The scio shoot and the seedling stem are then tied together by giving the ties in two places so as to produce a proper bend near the pla where grafting is intended to be performed. The seedling ar

GRAFTING MANGO ON TWO STOCKS. *Facing page 60.*

he scion shoot are left in that position for about ten days. It .elps the rootstock stem and the scion shoot to remain in position ill grafting is done. After this period of about ten days, a thin lice is taken off both from the rootstock and the scion shoot vith a sharp knife. The slice removed is roughly of about one hird of the thickness of the stem or shoot. The exposure should iecessarily be of equal breadth and length in the seedling stem .nd scion shoot, and should be slanting and gently tapering owards the ends so as to give a perfect fit when the two are joined ogether. The exposed portions of both the rootstock stem and the cion shoot are then brought together face to face and tied first vith grafting tape or a strip of banana fibre and over it again vith twine. Tying with banana fibre (*sopat* as it is locally called) is neant to prevent any constriction developing on the tender bark of he grafted plant as a result of tying with twine directly over he bark. Tying with twine has to be as close and as firm as ossible in order that the cut surfaces may come into a very close ontact with each other and leave no gap in between. Over he twine, a mixture of mud and cow dung in equal proportion s smeared to prevent the evaporation of moisture from the sides r ends of the joint. In Gandevi taluka (Baroda State), a mixture nade of camphor (one part), *erio* (Aloe) (two parts) and fine arth (four parts) is applied possibly as a disinfectant. At times, mixture of camphor and assafoetida is also smeared over he joint, while some growers and nurserymen are also said to ave resorted to the use of grafting waxes made of paraffin, rosin, eeswax and tallow in different proportions. In South India, nany use paraffined cloth instead of banana fibre for the first ing and Aloe or ficus fibre for the second tying. Nurserymen, owever, are not generally particular about this. In Gujerat, ng cuts (4.5 inches long) are made on both the stock and ion shoots, which are tied together with the cut edges facing ch other by running thin coir string round the united ortion. Neither *sopat* nor any wax nor mud is applied on the ed portion. The grafts made in this way develop defective ints with deep constrictions (15).

The rootstocks and the scion thus joined are left undisturbed r about a month and half. The seedling rootstock is watered aily, but care is taken not to pour water on the graft-joints lest ney rot. The joint takes about 45 days to unite properly under

favourable weather conditions. The nurserymen allow 2- months before separating out the grafts. The scion shoot i detached from the parent tree gradually. To begin with, a cu is given to the scion shoot just below the graft-joint, about one third deep. If after about ten days of this initial cut, the scio branch is not found withering, the cut is deepened to about two thirds the thickness of the scion. If it is found withering, longer period is allowed to pass. In about three months c grafting if the scion does not wilt, the union is finally take as successful and the rootstock is headed off just above th graft-joint. Nurserymen often allow the rootstock also to grov until the graft is established in the field, in order that it ma nurse the scion for a longer time. It has, however, been foun at the Fruit Research Station, Gandevi that heading back c the rootstock before planting the graft in the open field help the scion to gain vigour much faster than when the rootstoc remains untopped. The cut ends of the rootstock and the scio are both properly trimmed and the grafts are left to establis themselves for about three months before they are planted ou in the field or sold away. The banana fibre and strin around the joint should be removed at the time of planting th grafts in the field. Grafting is done in March and the graft are detached and sold in July by commercial nurserymen in th Gandevi taluka.

When the rootstock seedlings in pots are taken near the scio trees, a suitable arrangement has to be made to bring the scio branches and the rootstocks together. If the former are clos to the ground there is no difficulty. Otherwise they are ben down to reach the ground by means of ropes and pegs fixed i the ground. If this measure is not feasible, a wooden platforn has to be erected and the rootstock seedlings have to be place on it close to the scion shoots for grafting purpose. In som regions, the potted rootstock seedling is tied to a strong limb c the scion parent close to the selected scion shoot. In som commercial nurseries as explained hereafter, the scion trees ar specially trained to dwarf size to facilitate grafting close to th ground level. Recently a metal grafting-pot-stand has bee devised at Kodur (Madras) to enable the enarching of scio shoots with seedling rootstocks without adopting any of the above mentioned methods. The stand is clamped to a limb of the scio

parent after which, an adjustable arm of the stand having the potted seedling is brought to the desired position. This device enables the scion shoots from all parts of the tree to be selected and utilised for enarching, and renders it unnecessary to incur any recurring expenditure on scaffold or platforms, etc.

Grafting programme

In the Bombay State, where there is a regular and fairly punctual rainy season, and consequently a definite planting season when the rains break, the following programme can be followed with success in mango propagation

1. Sowing mango stones for raising rootstock seedlings —June, first year,
2. Grafting on rootstock seedlings—September, second year, *i.e.*, after fifteen months,
3. Detaching grafts from parent trees—November to December, second year,
4. Grafts ready for planting in the field—June, third year.

It would thus take two years for the graft to be ready for planting out in the field from the time the stones are sown for raising rootstocks. Very often, grafts are left unsold in pots for a long time and this results in stunted growth. Such grafts are distinguished by the greater thickness of the stock stem and the sickly appearance of the plant. These grafts are not desirable for planting out in the field, although the nurserymen may try to dispose them off at a cheap price.

Preparing scion trees

A very handy method of getting a sufficient number of scion shoots for grafting on rootstocks grown in pots, is to plant the scion trees considerably close to one another. When they grow for about five years, as many twigs are utilised for grafting as possible, and then the main branches are headed off at a height of about five feet from the ground. The stumps thus left give rise to "brooms" of new sprouts just below the cut ends. These sprouts can be grafted by enarching to rootstocks grown in pots, as soon as they are sufficiently mature. When all these new sprouts are grafted and the grafts are severed, a new crop of shoots becomes available and can be used in the following season for grafting. Instead of cutting away all the new branches of a

tree at one and the same time, they may be headed back in batches and allowed to grow alternately, so that a continuous supply of scion material is assured. A low platform is erected to carry the rootstock seedlings in pots near the scion branches for the purpose of grafting. A large number of scions can thus be taken from the same mother tree over and over again for several years. Such trees, of course, cannot be expected to yield any fruits.

In order to economise the raising of grafts, some of the commercial nurseries in South India raise the scion trees by a special and almost similar method. Trees are planted close to each other with a spacing of ten to twelve feet between every two trees. These are periodically topped and their limbs pruned severely so as to develop a very low headed bushy tree with a large number of small shoots spread all round the top. In such a case, the potted seedlings can be placed right on the ground and grafted to the low-lying scion shoots. The pots are sometimes buried in the ground so that water may be applied to them at long intervals along with the irrigation turns of the scion trees. These various measures enable the South Indian nurserymen to raise mango grafts at a very much cheaper cost than in the Bombay Presidency. The relatively longer time taken to separate the grafts from the scion trees also renders it possible for the nurserymen to sell the grafts to the public very soon (one or two months) after the separation.

A serious possible defect of the abovementioned procedure needs to be stressed. The scion trees trained by these methods do not bear any fruit and as such the grafts are raised from scion parents whose productive capacity remains unknown. Whether these artificial methods of continued suppression of the bearing tendencies of the scion parent, and grafting to scion shoots of rather succulent nature and of very much accelerated growth habit will affect the future bearing capacity and growth tendencies of the grafts as compared to the grafts raised from old and bearing scion trees, is a point which has been raised by many. Even if the productivity be a genetic factor, subject to the influence of environment and culture only to a limited extent, the fact that the above practice provides scope for the unscrupulous salesmen to sell their plants under wrong names is sufficient to discourage it.

In Ceylon the cleft or wedge methods of grafting and Forkert (modified) method of budding are commonly employed, and they have superseded the previously adopted method of grafting by approach.

Other methods of grafting

In parts of South India also, the method of grafting varies in some respects from that adopted in the Bombay Presidency. The majority of nurserymen in Salem and Chittoor districts raise the mango seedlings in nursery beds, and transfer them to the pots a couple of months prior to the time of grafting. In order to cater to the regional demand for very large sized plants, some nurserymen use seedlings of three or four years of age, but a large number of the nurserymen however, prefer one to two-year-old seedlings. The potted seedlings are taken near the scion parent and lopped at a height of nine to twenty-four inches from the level of the soil inside the pot. A slip of bark with some attached wood is removed from the seedling, by placing the knife 2 to $2\frac{1}{2}$ inches below the lopped portion and then drawing it sharply upwards, thus causing gradual deepening cut inwards to the wood, so as to leave only a very thin slice of wood of $\frac{1}{4}$ to $\frac{1}{8}$ inch thickness at the lopped end on the side opposite to that where the cut began. A corresponding cut is made on the scion shoot, which is then attached and tied securely to the rootstock, the exposed portion of the scion resting face to face to and resting on the exposed part of the rootstock. The advantage claimed for this method of grafting which is similar to whip grafting is that the rain water does not find a chance to enter inside the exposed wood, but merely flows down the wrapped parts of the graft union, whereas in the method (enarching) as practised in the Bombay Presidency and described above, a portion of the rain water may settle down in the crotch formed between the seedling rootstock and the scion shoot over the bandage parts and ultimately may find an entry to the exposed wood. The grafts are not separated from the scion parent for about three months after the actual operation. Because of the heavy rainfall and humid conditions prevailing during the monsoon weather, it is not found necessary to water the pots of the rootstock daily in the West Coast of the Madras Presidency except during very dry periods. Some nurserymen in these parts do not separate the grafts for even a year, in which case the rootstock seedlings are not watered after about three

months of the grafting operation, and, therefore, are allowed to draw their nourishment from the scion tree.

Recently, it has been shown at Kodur (Madras) that grafting direct to the root piece of the seedling is possible in mangoes. This method is similar to the method of bench grafting practised in Europe and America on apples, pears and grape vines except that, in this case only a piece of the root about two inches in length is exposed and this piece is grafted to the scion shoot. This method of grafting is believed to produce grafts of more uniformity in growth and bearing habit, and of greater resemblance to the parent trees than the enarched plants, in which case a portion of the stem-piece of the rootstock is retained. If these assumptions are proved in the case of mango, it will offer a suitable means of raising uniform planting material on miscellaneous monoembryonic rootstocks of varying constitution for field experiments. For commercial plantations, such grafts may not be popular because of the relatively greater difficulty in raising them and also of the difficulty in planting them without possible damage to the graft-union submerged underground and frequently wetted by irrigation water. The latter difficulty may perhaps be overcome by delaying the planting of grafts for some years till the graft-union is hardened by age and growth.

Side, crown, and cleft graftings have also been practised in mangoes in India with varying degrees of success. These various methods of grafting have been tried particularly for top-working old trees of inferior varieties.

Various combinations of vigorous or dwarfing scions and stocks were made and girth measurements of these studied at Sabour. Results are reported to show that (a) considerable difference existed in the size and vigour of unworked seedlings, (b) the dwarfing stock had reduced the vigour of scion and (c) when the scion was of a dwarf variety both the vigorous and dwarfing rootstocks produced dwarf trees. Dwarf scion on dwarf stock produced considerably smaller sized trees than the combination of dwarf scion on vigorous stock.

Mango budding has also been attempted in several places with some promise of success. This method of propagation has attracted the attention of several workers all over the world on account of certain advantages over the methods of grafting. It is reported to be

Budding of mango

successfully practised in Queensland, Florida, Philippines, Java, Ceylon and Egypt with some success. Shield budding is said to be more successful than bark grafting or patch budding in some places, while modified Forkert method has appealed most in other places. However, it is said that square patch budding known as 'Spring' budding has been reported to be successful in Florida. In Jamaica it has been suggested that seeds or very young seedlings should be put in their permanent position and budded nine to eighteen months later. The patch method of budding has been shown to be wasteful, and the ordinary T-bud method is recommended in Jamaica. Shield, Forkert and a modified Forkert method have been tried at Kodur (Madras) with a great deal of success, but the commercial possibilities remain still to be investigated. Budding of mango seems to have also been attempted at the Saharnpur Botanical Gardens, Uttar Pradesh (151) and in the Madhya Pradesh as early as the year 1899 with very little or no success. In the State of Bombay, Burns and Prayag (25) report to have obtained only eight per cent success in the total number of buds inserted. At Sabour the best budding season was found to be June and July, when 75% success was achieved in experiments conducted there. Buds from current year's growth which have reached a certain stage of maturity have given higher percentage of success than those from one year old wood. Later attempts, however, have shown that with a trained hand and proper selection of rootstocks and bud-wood, a larger percentage of success is possible. For success in the budding of mango, a great hindrance is caused by the following facts:—

(1) The bark of the mango seedling is not easily separable from the wood inside until the stem has sufficiently matured.

(2) The latex which exudes from the wound caused in the mango stem coagulates rapidly, and unless the bud is inserted immediately after it is cut, a layer of the coagulated latex intervenes between the surfaces of contact, and prevents union.

(3) The mango bud is very sensitive to the effects of the changing season.

In order to overcome these difficulties, the mango rootstock has to be allowed to mature sufficiently before budding is attempted

on it. A seedling rootstock of about three years of age with diameter of an inch or more about eight inches from the bas was found to make a good stock for budding upon at Poona. Vigo rous plants in flush are to be selected for budding. Buds shoul also be taken from mature wood. The bud may be made t get plump, but not to open, on the selected tree by pruning th terminal growth of the shoot having the bud, at least a fortnigh prior to use. Wester (190) suggests that leaf blades of the selecte bud-wood must also be cut off at the same time and the lea stalk may be allowed to dry and drop off in time. By doing sc the buds on the selected portion swell up, in which conditio they are suitable for insertion and are in a very active state congenial for quick union. The selection of the bud-wood an the necessary treatment to make the bud swell upon it are bes done when the scion tree is or just about to be in a new flush The effects of the latex mentioned above can be prevented minimized or overcome by a dextrous hand sufficiently trainec for the operation by long practice, and by inserting the buc soon after its removal from the scion parent.

The seasonal effects on the success of budding of mango ar marked in this country, where the conditions of weather var widely. In Poona, the percentage of success of budding wa found experimentally on mango by inserting buds every fortnigh of the year. It was revealed from these trials that budding ir the months of August and September meets with the best results During these months, the temperature of the atmosphere range between 60° F to 80° F. The heavy showers of the rainy seaso begin to subside having saturated the atmosphere with enoug humidity, and the lighter showers at frequent intervals help t maintain the atmosphere cool and moist. Rains are, however not desirable immediately after budding is done, because any water which enters the joints may cause the newly inserted buc to rot and thus kill it. In the case of plants in the ground, a short break of rains after the buds are inserted is therefore very essential. Paul and Gunaratnam (115) report that an improvec method of budding mangoes in the nursery has been devised a the Farm School, Jaffna, Ceylon. Six months to one year olc seedlings are budded at a height of about 10 inches from the ground. Bud is inserted in the flap between two parallel vertica cuts and secured with waxed tape. Budding of mango wil

no doubt be a paying nursery practice. Besides, the operations being much less complicated than grafting, budded plants will be available for sale cheap. Recent investigations in different parts of India, particularly in Kodur (Madras) as also in Ceylon, point out to the possibility of the practice becoming an important feature of the mango nursery practice in this country. A large percentage of success in mango budding was obtained in Ceylon when done on some rootstocks than on others (109). During the rainy season (August-September) of 1935, 175 buds were inserted on new but mature shoots springing from old country seedling trees at the Modibag gardens in Poona. Of these, 35 buds took and sprouted by December, 1935. The trees were more than about twelve years of age. Their main branches were headed back to induce new sprouts to come up from below the beheaded region. Such sprouts were allowed to mature when budding was done. If this practice proves an economic success, as it certainly promises to be, top-working of old mango trees of wild and inferior varieties will also be an easy matter. Lal Singh and Naik (160) report that great success was achieved in budding mango seedlings *in situ* in the Punjab, while considerable work has been done in raising budded mango plants in pots and ground in Poona during recent years.

Preparatory tillage

Having selected the site for a mango plantation, the land is cleared of all wild growth. It is ploughed twice cross-wise, thoroughly harrowed and kept clean till the rains. As mango trees are also grown on hill sides or on the border lines of fields and other plantations, there is considerable difficulty in levelling such areas. At Ratnagiri the practice is to dig pits at required distances on undulated and sloping areas, without bringing them to level. In taking pits on slopes, the contour lines may be followed so as to restrict soil erosion and facilitate irrigation wherever possible. All tree growth near the pits is cleared off to provide an open area for the new mango plants to prosper.

Draining the soil

In ill-drained level lands, it may be necessary to provide artificial drainage either through surface or sub-soil drains. Shallow channels may be opened out across such patches or areas at suitable distances from each other, with a suitable number of catchment pits for preventing the washing of soil and finer soil fractions. Deeper

trenches or lines of buried porus earthen pipes, or underground channels filled with brick stone, boulders, and brush-wood and providing enough inter-spaces, to permit the percolation and passage of water, may form the subsoil drains. Such covered underground drains may be laid out in a manner so as to allow a free flow of all the water passing through them to an open drain of the same or slightly greater depth, which in its turn may be made to empty its water into a stream or tank outside the orchard limits. The trenches in which pipes or other materials are buried may be filled up with surface soil at the upper 10 or 12 inches layer, in order to render the plot unbroken and convenient for tillage. By opening up of a number of open and covered subsoil drains, it has been possible at the Fruit Research Station, Kodur (Madras) to reclaim a plot of about three acres, which was previously considered unfit for any crop-growing, and make it suitable for the raising of a thriving mango and citrus plantation. It was also found at this place that, subsoil drains filled with boulders were as efficient as those with earthen pipes, and cheaper in cost.

"Surface drains prevent the sweeping away of the soil from the surface, but care must be taken that they themselves do not become carriers of soil. One or more silt pits in the course of the drains will arrest the flow of soil and silt. Open drains may be made parallel to the slope, while covered sub-soil drains should be connected to these in a slanting manner across the slope, but not at right angles to them. The depth of the covered subsoil drains will depend on the nature of the soil. It is important to see that open drains are left clean and free from weeds. Drains are particularly necessary in areas subjected to heavy rainfall and where the soil is stiff" (25).

Spacing of trees

Spacing of trees while planting depends upon the normal growth which they make when they are of the full bearing age. At no stage of the plantation should branches of neighbouring trees be allowed to intermingle, if possible. Mango trees assume large size and branching is generally well balanced on all sides. A distance of 35 to 40 feet is essential for mango trees under ordinary conditions. In fertile alluvial soil, particularly along the coastal region, even a distance of sixty feet between trees is not uncommon. Often plantations are seen so over-crowded as not to permit sun's rays

to reach the ground as a result of close planting. Actual cultural operations are hindered in closely planted groves. Proper orchard hygiene is also not maintained. Consequently bearing suffers. The trees give shelter to stem borers and other pests and diseases. Close planting therefore necessitates heavy pruning of the lower branches, if not the complete removal of intermediate trees at a later stage, in case the plantation is to be kept in good health. It is therefore most important to give a proper spacing at the very outset. In the coastal areas, 40 to 60 feet distance is considered suitable, while in the heavier soils of the Deccan and Karnatak a distance of thirty feet may be enough for planting mango grafts. In Gujerat, cultivators are adopting a distance of 50-60 feet between trees in mango plantations.

Pits

When the land is prepared and the spacing decided upon, pits of 3 feet by 3 feet by 3 feet are usually dug at the required distances during the hot weather. The soil of the upper half of the pits may be kept on one side and that of the lower half on the other while digging. The soil near the surface has been naturally subjected to weathering conditions and its ingredients are, therefore, in a more available form for the plant than the soil below. These two heaps are usually inverted while filling up the pits so that the surface soil is placed first into the pit and then the subsoil. It is generally advised to keep the pits open to the sun and wind for a couple of months at least before planting. This exposure is thought to help the interior of the pits to get properly "heated up" and weathered. If this is not possible, some kind of rubbish or brushwood is burnt in each pit. Burning in this way may improve the texture of the soil, and add ash (potash) to it. Before the pits are filled up, the two (soil and subsoil) heaps of soil are each thoroughly and separately mixed with about 25 lb. of well rotten cattle manure, one and a half pounds of bone meal* and two and a half pounds of wood ash. Wood ash may not be necessary if the pits are already burnt with brushwood, etc., as stated above.

*Bone meal of high quality can well be prepared by collecting stray bones of dead animals on the village side and storing them until required for use. These bones may be heaped with dry leaves and brushwood pieces in alternative layers, and partially burnt to make them brittle. When they are half burnt, they can be easily broken and powdered in an ordinary mortar

Filling up of pits should be done before the break of rain so that the rain water does not accumulate and spoil the improve structure of the soil. The original bulk of the soil may be foun to have increased by the addition of the manure. Hence if an soil remains in excess after the pits are filled, it may be kept i reserve near the pits for use if necessary after planting is don In order to facilitate accurate spacing and planting in straigh lines, it is advisable to drive a peg in the centre of the pit as guiding mark.

It is the practice in other parts of India and also in som other countries, not to use any manure while filling pits. Manur is usually added a year after planting or 6 to 12 months pric to planting. This practice seems to be suitable where whit ant trouble is severe. The placing of manure near the root at the planting time is also considered at these places to b adverse to the new rootlets. Fresh manure gives out hea during the process of decomposition which may be injurious t the roots. It is, therefore, considered advisable to mix th manure in the soil some time in advance of the planting date.

Planting

Mango trees may be raised either *in situ* or by planting ready made nursery grafts. The former practice is theoretically to b preferred to the latter, whenever, and wher ever possible. *In situ* plantations requir mango stones to be sown in the pits about two years ahea of grafting. When the seedlings thus raised, attain a heigh of about two or three feet, they can be grafted upon wit scions of the desired varieties. Plantations of the secon type are raised by purchasing grafts prepared in pots i nurseries and planting them out in the field direct. Plantin of grafts thus saves considerable amount of time, labour an care. But *in situ* plants are believed to produce trees of much superior stand and root system.

Pits are prepared and filled up in the same way as describe above for both methods of planting. Soon after the break o rains or even a few days earlier, four or five well develope

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mill. It may be noted that by burning, the bones do not lose to any conside able extent their phosphoric acid for which they are meant. This practice, followed, will be much cheaper than buying ready-made commercial bone mea Besides, it will provide some employment in the villages, help village indu tries and thus promote rural uplift.

tones of country mangoes *ripened on the trees* are sown in the centre of the pits at a distance of a few inches from one another. Sowing may be ione about two inches deep. The surface soil should be well ›ressed after sowing. Watering by hand is essential till the stones ;erminate and plants establish, unless sowing is done after the ains have set in, and rainfall is sufficient to keep the soil moist.)n germination, the seedlings are allowed to grow for two or hree months; and when they are about a foot high, only the trongest seedling is retained, and the rest clipped off close to he ground or carefully grubbed out from each pit.

In situ plantations of mangoes

The soil round the base of the plant in each pit may be stirred t least once a month. Some kind of liquid manure is given to he plants after each stirring. This treatment is said to invigo-ate the young seedlings, and if continued with adequate irrigation fter the rains, the seedlings may become ready to receive the cion in a year when they attain a stem thickness of half an inch r so at the base. It is, however, considered unnecessary to pply any liquid manure, if the soil in the pits has been mixed ith some sort of manure a few months before actual planting. s it is usually difficult to regularly bestow sufficient care on e plants scattered about in the field at long distances, it is referable to allow the seedlings to grow undisturbed for another ear. They can then be grafted or budded upon.

Grafting on such seedlings can be done either by the side-rafting method or by enarching. Except in the coastal tract here the atmospheric humidity is high for a long time, the side-afting method is not generally very successful. In other tracts, ady-made nursery grafts are purchased and their scions are afted to the rootstock plant raised *in situ* by the simple proach (enarch) method. For this purpose, it is desirable to y grafts with more than one branch on the scion, so that a ngle graft in pot can be utilised to graft more than one rootstock the field.

After the union is effected and the graft is separated from e scion parent plant in the pot, the rootstock plant in the ound is headed back to the graft-joint in due course of time. bout three or four months after separation the wrappings ound the graft joint are removed carefully. As the scion in is case has the advantage of growing on a free and extensive

root system of a vigorous seedling, the result is a far rapid growth superior to that observed in the case of plantations where ready-made grafts are planted.

Although, as discussed above, planting mango *in situ* is desirable, it is not much in vogue in actual practice. Ordinarily, growers decide on raising their mango plantations without much preliminary preparation or thought and follow the easiest and quickest method of doing it. The land is prepared, pits are taken and ready-made nursery grafts of the desired varieties are purchased at considerable cost and are planted. The owner has the satisfaction of possessing the varieties he wished for right from the very beginning of the plantations without a great deal of effort on his part in raising the grafts in nursery. This practice naturally creates a demand for nursery grafts and has consequently given rise to a regular and growing nursery trade.

Planting of nursery grafts

The method of planting nursery-made grafts in the fields direct is obviously simpler. While planting, the pots are broken or removed carefully so as not to break the ball of earth inside, lest the roots of the plants get damaged. Pieces of potsherds which usually get entangled in the coiled roots of the pot plants, are also carefully removed before planting. The grafts are then planted in the centre of the pits, burying them to as much depth as was originally in the pot, that is up to the collar. Planting deeper is not at all desirable, as any stem portion which enters the soil is liable to the attack of white-ants and other insects and may also get its bark rotted in the wet soil. It is definitely harmful to bury the graft joint of the plants in the soil as this is the most sensitive part of the stem. Not only that, the graft-joint should also be kept above the zone which usually becomes wet by irrigation water. It is a wrong impression that by burying the graft-joint, the risk of the graft being broken by strong wind is overcome. In order to protect newly planted grafts from high wind, which shakes the plant violently it is suggested that a strong bamboo or any other stick, which has previously been smeared with coal tar may be planted near each graft, and the graft tied to it rather loose in two or three places. It is also suggested that wherever possible, hedges or windbreaks may be raised around the plantation. At the time of planting or a few weeks later, the *sopat* and string which were used in tying the graft-joint should be removed.

The root system of the plants raised in pots is necessarily oorly developed, twisted and coiled in its search for food from the imited quantity of soil available to it. It is not infrequently ut and trimmed, if not torn, by nurserymen to prevent the tap oot from entering the soil through the drainage hole. The lant consequently suffers and becomes stunted in growth, specially when allowed to remain in pots for too long a time. or this reason, it is always desirable to buy grafts which have emained in the pots for not more than about six months after he scion is detached from the parent tree, or that have been egularly repotted into larger sized pots at an interval of every ix months up to about eighteen months after grafting.

hoice of grafts or planting

When nursery grafts are purchased for direct planting in he field, they should be properly selected. Such grafts, it may be repeated here, should not have remained in the pots for too long a time after the scion is detached from the parent tree, lest their rowth is stunted and they look sickly. Grafts which have both the ootstocks and scion of uniform thickness and erect and straight rowth should always be preferred to those, the component arts of which, do not bear any proportion to each other. The raft joint must be fairly long (about two to three inches) and hould exhibit evidence of a perfect union. When the grafts ave not been long in the containers after the scion has been etached from the parent tree, the graft-joint is generally overed with the grafting tape or string. While buying the rafts, one or two of them may be untied and the joints spected carefully. When union is perfect, the rootstock and e scion will be seen clinging tightly together on all sides of e joint. New callus or healing tissue will also be seen eveloping on the border of the joint. If union is defective, e attachment of the scion and the rootstock as well as the allus formation will lack uniformity. Sometimes along the order as well as at the ends of the joints there may be a endency for the separation of the rootstock from the scion, here normally there should be close attachment. After making neself sure of proper union of the rootstock and scion, the joint ay be again tied if necessary, in order to protect it further for ome time until the graft establishes itself in the field. This step s unnecessary where the union is perfect and the graft has been

separated from the scion parent at least six months before the planting date. Grafts with a single, strong, mature, healthy and vigorous scion branch should always be preferred to those with weaker scions having many branches. The scion should never be thicker than or otherwise disproportionate to the rootstock in a graft. The whole plant should be such as if it were a well-knit combination of not dissimilar entities, forming a naturally growing plant of normal health and vigour.

In parts of the Ratnagiri district and the province of Goa, there prevails a practice of grafting a single large scion branch on two or three small tender seedlings raised in one container. The idea underlying this practice seems to be that a large mango graft can be easily obtained in a shorter time in this way than by allowing a single rootstock to attain the required size, and that two or three small seedlings can serve the purpose of one suitable and proper-sized rootstock for the scion. It is, however, found by experience that this is a wrong practice, in that it adversely affects the future tree, although it may give the nurserymen good profits for the time being. The scion in these cases becomes top heavy and the rootstock seedlings can rarely provide a strong and uniform support for it. This practice appears to be slowly dying out.

A large number of grafts of mango varieties is annually imported to the Bombay Presidency for sale from the State of Madras. These grafts are usually very large in size, being from three to four feet in height and are sold comparatively cheap. They are usually despatched immediately after they are separated from the scion parent tree. Growers are tempted to buy them, but the result is that many such grafts die soon after they are planted out in the field. Though these grafts are prepared on single rootstock seedlings, unlike in some nurseries at Ratnagiri, they are grown in small earthen pots for easy and economic transport. The pots are too small for the proper development of the roots. The soil contained in such pots is also too little to ensure an adequate supply of nourishment to the comparatively large plant. The plant, therefore, has a poorly developed root system. If, however, these plants are transferred to larger pots and kept in shade for two to three months before planting out, they are likely to attain their normal growth. Otherwise the grafts are generally unable to adapt themselves to the new

ıvironments. They, therefore, succumb at an early stage to e great disappointment of the planter. Instances can be ted where hundreds of such grafts were purchased and planted the field, and in spite of the very best care bestowed on them, ıly a few remained at the end of a year after planting.

Considerable difficulty is experienced in despatching mango afts to distant places for planting. Apart from the high transportation charges, long-distance shipments of parcels involve a great deal of risk to ant life. The following method of despatching living plants post has, therefore, been worked out to reduce loss ıd economise transportation expenses. Strong healthy grafts one to two feet in height are selected for this purpose. They e kept in the open for full exposure to the sun and wind and e watered sparingly for about a fortnight. After they are ıardened" in this way all the leaves are clipped off, leaving ıly small leaf stalks. They are then taken out of the containers th the balls of earth intact and are made to stand in water r a few hours so that all the adhering earth can be carefully ıd gradually shaken off the roots. A suitable box is got epared for packing in which a lining of oil paper followed another of blotting paper, and over it a wet piece of gunny ɔth are laid. Inside these a fairly thick layer of well moisted moss, cocoanut fibre or grain husk is spread and the plants e then placed over these in position horizontally. A layer of ɔss is spread over the grafts, which are then covered at the p with wet gunny cloth, blotting paper, and oil paper as he bottom and sides, and the box is closed finally. It is n ready to be labelled and despatched to destination by post. rcels of maximum weights of twenty pounds each can be by post in this country. About forty mango grafts of modere size can be packed in each parcel. On receipt of the parcel, addressee who can be intimated of the despatch sufficiently ıdvance, should open it with the least possible delay. The plants ɔuld be taken out by him and submerged in water for about hour. They may then be planted in suitable pots one by one. e soil used in these pots should be pure sand mixed with face soil in equal quantities. The pots are then copiously tered and kept in a very cool and shady place, preferably a shallow pit in the ground of a size sufficient to hold all the

ransport of grafts

pots standing together side by side. The sides of the pit are sprinkled with water before the plants are introduced in it. A wet canvas or gunny cloth is spread over the plants after keeping them in the pit. The pots are watered lightly as and when required. But sides of the pit as well as the gunny cloth canopy are kept moist by spraying or sprinkling water at frequent intervals during day time in order to provide a damp atmosphere to the plants. Gradually, and in the course of about ten to fifteen days the buds on the plants swell and sprout. The plants are then gradually exposed to the atmosphere, the gunny covering being removed at the beginning for short periods late in the evenings and early in the mornings only. When the plants have formed some leaves, they are taken out of the pit and kept in a shady place without any covering for some time, till they are considered fit to be planted out in the open. Both the processes of hardening at the place of origin and of reviving at destination are rather delicate operations that require some care and adjustment for success. With some experience, however, the operations will be found simple enough to be followed by laymen of average intelligence. The postal system of despatching fruit plants of an evergreen type as mango has yet to become popular in this country. There is, however, no doubt that it offers several advantages over the prevalent methods, particularly in regard to the despatch of the plants to foreign countries.

Irrigation

Mango seedlings raised and grafted *in situ*, as described before, have to be watered throughout the dry periods until they come to bearing, as in the case of nursery grafts planted in the field. After bearing commences, the trees are generally left to depend upon natural precipitation only. On the hill slopes of the Konkan tract, water is generally given to these trees by carrying it in earthen pots from the wells at the foot of the hills. This method of hand watering is very laborious and costly. Special earthen or stone structures are sometimes raised at the base of the trees on the hill slopes of Konkan in order to protect the trees from being dislodged by strong and frequent winds. Such mounds of earth also hold moisture for the trees during a large part of the dry period of the year. Water is generally given by hand on the top of these mounds, which are two to three feet high with a diameter of five to ten feet.

A KALTA OR MOUND OF EARTH AROUND THE TRUNK OF A MANGO TREE, SHOWING ROOTS. THIS IS A FEATURE OF MANGO CULTIVATION IN THE RATNAGIRI AREA.

On the Deccan plateau to the east of the Western Ghats, mango plantations are generally raised on level ground. The most common practice here is to buy nursery grafts and plant them in pits. Watering follows, unless it rains soon after planting, and is continued by well or canal irrigation at regular intervals of eight to ten days. When the trees grow up and reach the bearing stage artificial irrigation is generally discontinued, as they develop by then an extensive and deep root system, capable of absorbing enough moisture from the soil to feed the trees. In the Indo-Gangetic plain and South India, mango grafts are rarely watered after three to four years of planting. On the hill slopes of the Malabar Coast, it is not uncommon to hand water the tree during hot and dry periods as in the Konkan tract of the Bombay State. Higgins (68) suggests that from fifty to seventy inches of irrigation per year should be given to mango trees, and the heaviest irrigation should be given from the time when the flower buds are about to open until several weeks after the fruiting is over, withholding large amount of water during two or three months preceding the flowering season.

Manuring

No definite standard of manuring mango grafts has yet been evolved either by common practice or by experimental investigation. Various doses are being tried of different mixtures including bones (whole or powdered), farm yard manure, slaughter house refuse, fish manure, etc.

The underlying principles seem to be to provide for the tree the three important ingredients, namely, nitrogen, phosphoric acid and potash, in one form or other, as they are commonly deficient in Bombay soils. Emphasis is, however, laid on the supply of bones to mango trees at all stages of growth. Bones are buried round the trees even at an advanced age in order to rejuvenate them. Burns and Prayag (25) state:—

"We recommend twenty pounds farm yard manure per tree for a year old tree, and then an increase of ten pounds per tree per annum, upto hundred pounds per tree. Similarly, bone meal at five pounds per tree for one-year-old, and an increase of one pound per annun upto fifteen pounds per tree. Ashes at ten pounds per tree and increased by two pounds per annum upto thirty pounds per tree."

These recommendations have not yet been adopted by growers. Whatever manure is applied, it shound be well mixed with the soil at the feeding zone of the trees and applied in the beginning of the monsoon, when rainfall is moderate. In heavy rainfall tracts, manure is best added after the severity of rains has abated, that is, in the month of September or so.

After the trees come to the bearing stage, it seems necessary to maintain their vigour by the application of suitable fertilizers once in every two or three years if not annually. Nitrogen and phosphoric acid appear to be the main requirements of the plants for this purpose and can be supplied in the form of bone meal and sulphate of ammonia or Niciphos II grade. It is desirable to use farm yard manure in combination with these artificial fertilizers. The following doses of manures for trees about twelve and twenty-five years of age are recommended by Wagle (183):

		Trees of 12 years of age.	Trees of 25years of age.
I.	Bone meal,	15 lb.	20 lb.
	Sulphate of ammonia,	5 lb.	6 lb.
	Farm yard manure.	50 lb.	75 lb.
or			
II.	Niciphos II grade,	9 lb.	12 lb.
	Farm yard manure,	50 lb.	75 lb.

"The doses for smaller or bigger trees may be changed proportionately according to their age."

The application of common salt as manure to mango trees is a practice with some growers in Konkan (57). Woodrow (193) has recorded that the mango growers near Bombay apply ten pounds of common salt to each tree in the month of September. The practice is stated to be helpful or at least not harmful in a moist climate with a heavy annual rainfall. In the drier tracts of the Bombay State this practice does not exist, nor is it in vogue in the humid zones of South India. Paranjapye (107) reports that in certain cases where the Konkan practice of applying common salt was followed in the Deccan, the trees actually suffered from its deleterious effects. Burns and Prayag (25) record the result of an experiment they carried out at Poona, wherein they state that the application of common salt seems

to have no effect on the time of flowering. They dissent from the opinion of Gonehalli (57) who explains that the use of salt is "to keep off white ants, to retain soil moisture and to arrest vegetative growth". Some land owners at Ratnagiri observe the following rotation in manuring their coconut and mango trees :

1st year	Cattle manure
2nd year	Fish manure
3rd year	(Salt 10 pounds per tree)

Some manurial experiments on mangoes carried out at the Fruit Research Station, Sabour, Bihar, reveal that nitrogen in the form of ammonium sulphate is the most effective in increasing the flowering of mango trees, and that the best time of application of nitrogenous manure in any form is the month of June.

In Florida, two applications of a pound each of a fertilizer containing about 6 per cent nitrogen, 6 per cent phosphoric acid and 4 per cent potash during the first year after planting are recommended (144). The first application is made in spring and the second in summer. The amount is doubled in the second year and gradually increased until the trees reach full bearing age. Mature bearing trees are given annually from twenty to forty pounds of this fertilizer divided into three or four applications. No fertilizer is, however, applied during the blooming and early fruit-setting period. Macmillan (84) recommends a mixture containing one part blood meal, one part superphosphate, half part bone meal, and one part sulphate of potash to be applied at the rate of six ounces per tree which is one year old, twelve ounces each to those which are two years old, and four pound each to trees six years old. Experiments carried out for over six years at Sabour show that the application of phosphorous and potash singly or in combination had little effect on growth, but nitrogen in combination with either or both of these elements had better effect on growth than nitrogen alone. Flowering further was observed to be directly proportional to growth (143).

The value of such trials may not be of widespread application because of limiting factors such as diversity of environments and multiplicity of varieties. The Sabour trials with trees of a particular age and vigour cannot also hold good

with other trees of different age and condition of growth. Above all, the cost of manures and fertilisers may render their application not always feasible in mango groves.

The young mango trees are planted in most parts of the Bombay Presidency with a spacing of over thirty feet, which means that there is considerable open space left between them. In order to utilize this space and to earn some income to pay for labour, manure, etc., some kinds of seasonal vegetables or short lived fruit trees may be grown between mango trees. The usual practice is to grow *bhendi* (*Hibiscus esculentus*), *Guvar* (*Cyamopsis psoralioides*), *Kulthi* (*Dolichos biflorus*), groundnut (*Arachis hypogaea*), peas, etc., during the monsoon every year until the mango trees cover the interspace fairly well by their own spread. Perennials which shade the young trees are not desirable as inter-crops. In the Modibag Gardens, in Poona and at the Sabour Fruit Research Station, Bihar, papaya trees have been grown as an inter-crop between mango trees with no harmful results. A very intensive system of cropping was also practised at Poona wherein seasonal vagetables such as Knolkohl, cabbage, radish, etc., or fruit plants such as cape gooseberry were grown together with papayas in mango plantations. When the mango trees grew up, a dwarf variety of banana was planted between the mango rows. In Gujerat, near about Amalsad crops of pineapple and black pepper (*Piper Longum*) are grown in mango groves. In the Baroda State, inter-crops of sugar cane, *suran* (*Amorphophalus campanulatus*), ginger (*Zingiber officinale*), turnip and later on pepper, and pineapples are usually grown.

Inter-crops

In the warmer regions of the Presidency of Bombay where the atmospheric temperature exceeds 110°F for several days during the summer, small mango grafts are sometimes planted at the usual distance in banana plantations. Banana plants shade and protect the young mango plants until they are established; after the mango trees are two years old, the banana plantation is removed. This practice is fairly widespread in Bijapur and Khandesh districts. Collins (32) has also recommended a similar practice for Porto Rico. In the Punjab and Gujerat, bananas are planted by the side of newly planted mango grafts and sometimes of mango seedlings also as a nurse crop. In the Surat district, sugarcane is taken as an inter-crop in well drained

YOUNG TREES ENTIRELY HIDDEN IN THE INTER-CROP OF JOWAR (ANDROPOGDU SORGHUM), AN UNDESIRABLE PRACTICE.

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soils. Growing of mango together with crops of entirely varying requirements for moisture, culture, etc., as sugarcane and banana is a practice difficult to be justified as sound; but with an adaptable and hardy fruit like the mango no marked ill-effects have been observed due to such inter-cropping methods. The question of inter-cropping does not, however, arise when mango grafts are planted in a line on the border of fields or other plantations, as is very often done.

Inter-tillage

Mango trees, when young, require that their basins should be frequently stirred after irrigation. When they are established, however, the inter-space is ploughed once or twice in the year and left exposed to absorb rain water, as and when it may be received. In actual practice, manure is rarely applied regularly to grown up trees, and whatever dry leaves drop off annually beneath them, are ploughed into the soil. Even this is not possible on rough hill slopes as in the coastal tract (Konkan), where adult mango trees are simply left to themselves except for gathering of the fruit crop. Proper tillage is only given on level ground where inter-cropping is also possible. Clean cultivation all through the year is never practised in mango groves nor is it advisable, as it results in a too rapid depletion of the soil humus. Clean cultivation during the dry seasons combined with the growing of cover crops during the rainy seasons is recommended for both citrus and mango groves in Florida (144). Cover crops, however, can be grown with difficulty in bearing mango plantations, and at any rate are not profitable except when they are grown for green manuring purposes.

Pruning

Mango trees are not ordinarily pruned. If left to themselves, most of the seedling trees of mango are seen to develop a very graceful dome shape with a clean straight trunk. Grafted trees of some varieties, however, branch low and spread out without any regular shape. Often grafted trees send out large branches close to the ground and it is difficult to do any cultivation below them. Such branches may well be utilised to take scions for grafting purposes. Later, the thicker branches also may be pruned close to the main trunk so as to clear up the base of the trees for cultivation. Several varieties in the Uttar Pradesh, Bihar and the Madras States are erect growers with a fairly high

head and, therefore, the above measures are unnecessary in their case. Burns and Prayag (25) state—"We have studied several hundreds of flushes from their inception to the time they flower, and are convinced that there is no possibility of pruning for flowers, as any kind of pruning may lop off a potential flower bearing branch". Mango stems, however, have to be pruned to varying extents when they are severely affected by loranthus and stem borers, as described elsewhere.

Thick branches of seedling mango trees have also to be pruned back heavily in order to stimulate the growth of a large number of vegetative shoots for grafting upon. When these shoots are mature, they are grafted to scions of superior table varieties. Budding is also fairly successful on such shoots if it is done in the proper season. This practice is known as top-working and is described elsewhere. It is mainly resorted to when large seedling mango trees have to be converted into good types for economic reasons.

Transplanting of mango trees

Occasionally, large mango trees are used to fill up gaps in regular plantations. It is difficult to shift large trees to long distances, and hence transplanting has to be done within close limits. Trees selected for this purpose have to be severely pruned of all the leaves and smaller branches before they are lifted. The remaining portion is then wrapped with straw and moistened to prevent it from drying up. A cirular trench is dug round the trunk of the tree about two or three feet away according to the size of the tree. This trench is deepened and cut inwards. All roots coming in the way are cut off. The conical ball of earth round the roots of the tree thus prepared is then carefully wrapped in gunny cloth and coir to prevent it from breaking. The tap root of the tree is then cut, and the base of the earthen ball also included in the gunny cloth wrapped and tied well. The whole tree with the ball of earth is then lifted carefully by means of a crane or levers and shifted to the place reserved for its planting where a suitable pit is kept ready to receive it. Planting is done in the new pit, and all soil filled into it is well pressed and the trunk of the tree is supported from all sides with bamboo or other kinds of support, to keep it steady against wind or other physical disturbances. Copious water is given to the tree and the covered stem is also sprayed

HEALING OF WOUNDS ON A MANGO TREE, AS A RESULT OF PRUNING THE BRANCHES CLEAN TO THE BASE WITHOUT LEAVING ANY STUBS. *Facing page* 85.

th water to keep the straw moist. This will hasten e buds to sprout. Excessive spraying with water may cause e bark to rot and the tree may die in course of time. hen the buds sprout and new foliage is formed in about two onths from transplanting, the straw covering is removed and e tree is allowed to grow freely in its natural condition. ansplanting large mango trees is best done when the atmosphere cloudy or when it is drizzling during the monsoon. Trees out five years old or under may be transplanted very easily thout using straw and taking other precautions described ove. Seedling mango trees growing in the jungle can be ifted to cultivated areas according to the method described ove and used as rootstocks for grafting upon with superior rieties, so as to secure large trees in a relatively short time. ut this is unlikely to be economic in most places.

ejuvenation of d mango trees

It is a well-known fact that mango trees live for a hundred ars or more and grow to huge dimensions. Popenoe (124) referring to the records of Charles Maries states that mango trees were found in North India in thrifty condition even 300 years after anting. Old trees have a tendency to develop hollows in their unks and main branches starting from the crotch or the point bifurcation. Rain water is deposited here and this causes the rk and the wood inside it to rot; and as the process continues ar after year, large cavities are formed. Similarly, when a anch is broken by wind or by other means, the untrimmed b left behind usually rots and dies. Gradually, a cavity may formed at this point too, which may later run deep into the in branch. A historic *Borsha* mango tree of huge dimensions, puted to be over three hundred years old at Kalamsar in East Khandesh district, had one of its three main branches oken by wind. In course of time, the main trunk developed ollow in which three to five persons could enter at a time. e whole tree was in danger, but it has now been saved by the lowing method: All the dead wood was cut and scraped until the living tissue was reached. The exposed portion s smeared with coal tar as a disinfectant, and the cavity was ed with lime mortar together with several well baked cks to make up the bulk. When the cavity was properly filled thout leaving any interspace between the bricks, the opening

was neatly plastered with cement. This operation gave strengt to the remaining portion of the trunk as callus formed all roun the cement facing. This process has been adopted in filling u several tree cavities with great success at the Ganeshkhind Fru Experiment Station, Kirkee. Neat trimming of all stumps o broken or cut branches and applying tar immediately afterward on the cut surface in order to enable the trees to form healin tissue (callus), are, therefore, desirable measures recommende to prevent the formation of cavities. Hot tar is dangerous anc should not be used over living tree parts.

Old trees and sometimes even young groves of mangoes ar seen in many parts of India in a neglected condition with scragg and unhealthy branches full of loranthus and stem borers. Suc groves cannot be expected to be remunerative, even if the tree are of the superior table varieties. Rejuvenation of thes trees can be accomplished by properly ploughing and cultivatin the land, removing all borers and loranthus by the method explained elsewhere and by applying the following dose o manure per tree of 15 to 20 years of age at about the commencement of the rains:—

20 pounds of bone meal,
200 pounds of well rotten farm yard manure, and
5 pounds of oil cake of any kind.

The above dose may vary according to the age and size of the trees.

Top-working by various methods is reported to have given uniformly successful results at Sabour. Top-working old mango trees by cleft-grafting, budding or bark grafting is also recommended by some persons. It has to be remembered, however, that top-working an old tree in a declining state will serve no purpose whatever, unless steps are taken to invigorate the tree by better feeding and grove culture. Old mango trees in weak health can also be invigorated by infusing fresh sap o younger seedlings into them. The method adopted to achieve this object is as follows: Several young mango seedlings or stones are planted close to the trunk of the tree. When the seedlings have grown for two or three years, they are headed off at a height of two to three feet from the ground level. The cut ends are then shaped to a wedge form to a length of two inches in the fashion of the ends of a fountain pen facing the tree, and insertec

DOUBLE GRAFTING OF MANGO.

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to the bark of the latter and tied up. The insertion of the edling stem pieces should be done in a manner that the exposed les of the seedling stem are fairly embedded between the inner ood and the bark of the tree. In course of time, the seedlings t grafted to the old trees, and serve as its feeder trunks.

In the Baroda State and the Gujerat districts of the Bombay esidency, a common practice of strengthening nursery made afts planted directly in the field is to plant one or more seedigs near the graft, and when both the seedlings and the graft ve grown for sometime, the seedlings are grafted to the branches the graft by the enarch method. The seedlings are headed f when the union is complete. The branches of the original aft are thus able to draw plant food through the new seedling ot-stocks, and consequently grow with increased vigour. ie debility of the original graft, if caused by its twisted and poor ot system, is thus remedied.

owering and ilination

Marloth (88) observes that the structure of mango flower ovides for pollination by insects. Self-pollination has been observed to some degree in a few varieties. Research has so far not been able to explain the failure of certain varieties to flower normally and gularly in S. Africa. Under normal conditions, inflorescences the mango develop from terminal buds and if the terminal ds are removed during the flowering period, inflorescences are oduced by axillary buds which would normally remain dorant. Experiments on girdled and decapitated branches in-ate that, when leaves are present above the girdle, floral luction takes place in the axillary buds in a period between e and four days after the treatment (136). According the observations made at Sabour (Bihar), fruit bud differen-ion was first detected at the end of September and prossively increased upto the middle of November. This s not explain how some of the new growths emerging ards the close of the calendar year also produce blossoms hin a couple of months of their emergence.

iodicity of ring in ngo trees

Mango trees are notorious for not bearing a good crop ually. Some trees in the same plantation may bear heavily in one year, while others may not. Even on the same tree, a few branches only may bear fruits in a year and the remaining branches

C. F.—8

may bear in the next year or a few years later. The cycle periodicity of bearing is alleged to be completed in thre years in the Bombay Presidency, except in the case of th *Totapuri* variety where it is said to be completed in tw years. This, however, does not hold true in other parts of India Local conditions of soil, climate, cultivation and other facto may wield varying influence in different mango regions. Th problem has yet to be studied experimentally before any defi nite idea can be given.

According to some authors biennial bearing is not the in herent feature of many varieties of mangoes and that an optimun crop can be secured every year, provided the tree has mad normal vegetative growth under natural conditions in the pre ceding season. The work carried on at Lyallpur and Kodur len force to the belief that the effects of so called alternate or irregu lar bearing in mangoes can be minimized by a suitable cultura operations programme. It was noticed at Sabour that in the case of old trees with "alternate bearing" habit, treated tree gave more flowering than control in the following year, but in the case of young trees just coming into bearing, no beneficia effect was observed. It was also observed that flowering could be induced in the "off" years by ringing in the "on" years. Half inch ringing of branches in the "on" year in August followed immediately by manuring with farm yard manure plus ammonium sulphate produced better results than "ring ing alone" and "manuring alone". From an experiment in progress at Bihar (Sabour) the results indicate that ammonium sulphate plus farm yard manure applied after harvest (June) gave significant increase in flowering. The treatment given annually during five consecutive years increased the level of flowering both in the "on" and "off" years, bu showed little effect on the so called biennial rhythm. Applica tions are now being made in the "on" years only (143)

Hartless (64) has shown that at Saharanpur, mango tree bore during the period from 1886 to 1912, an average crop in three years, heavy crops in nine years, and poor crops in fifteen years. Insect pests, drought in the spring, frost and cold untimely rains and excessive growth favoured by climate are the causes that were responsible for crop failures. It is also revealed in the records collected by Hartless that on tw

ccasions, two abundant years occurred in succession, and on oth the occasions three bad years had preceded the phenomenon. hese facts show that in some parts of India, alternate earing or periodicity of bearing, strictly speaking, does not ther exist, or if it does exist, it is subject to the modifying fluence of a number of external agencies like pests, diseases, nd weather conditions.

It has also been shown in Bihar (16) that a heavy year in ango crop is obtained in that Province once in six years. xperience in other parts of India also seems to reveal that e periodicity of bearing is not a regular phenomenon in all ango varieties, and under all conditions. There are, no doubt, off" and "on" years occurring at irregular intervals, but to hat extent these are caused by the various factors mentioned ove is a point on which light has yet to be thrown. Wagle 83) records his observations in the Bombay Presidency in this gard as follows:

"Mango trees usually bear in alternate years, but as a result manuring trees, particularly, of ten to twelve years of age, they gan to bear in successive years." He gives a three-year record the yield of several trees to substantiate this statement, and ds that the vigour of the trees is very well maintained by anuring in spite of their annual bearing. He attributes the provement in bearing to production of more complete wers developing into mature fruits later on as a result of anuring. He experimented with sulphate of ammonia pounds), superphosphate (2 pounds), farm yard manure baskets of 40 pounds), and Niciphos II grade.

Popenoe (124) has also drawn the conclusion that the ure of crop in mango is due to physiological causes nnected with nutritional conditions as influenced by changes soil moisture and food supply, principally the former." After eavy bearing probably the tree becomes weak and cannot duce blossom during the succeeding year until it can recoup lost vigour. As shown above, a proper supply of the chief nt food ingredients in the form of manures, coupled with quate irrigation may improve the situation and cause the s to bear more frequently if not annually. Hartless (64) recorded that at Saharanpur, the finest year for mango was one that followed an early closing of the monsoon. The

relation between the growth of the previous season or the cessation of the growth activities in that season and the productivity in the succeeding season is indicated from the above observation.

Smudging

The practice of smudging is reported from the Philippines. Dry leaves, straw, brushwood or weeds are used as fuel to produce a thick pall of smoke. Sometimes, small quantities of sulphur are put in the fire thus caused. The tree is smoked heavily and continuously day and night for a week. Thereafter, light fires are made morning and evening for about a month or until the trees come to bloom. If the trees fail to set crop, a second smoking is given. Borja and Butista (18) obtained best yields by smudging the trees in December and January. November smudging was not successful. Trees not producing flowers within about fourteen days of continuous smudging will not, it is stated, do so at all in that season. Gonazalez (55) reports from the Philippines that mango trees can be made to flower at any time of the year by smudging. It was commonly believed that it is the smoke that induces the blooming, but work done in the Philippines indicates that it was the heat and not the smoke that induced flowering, the number of flowers produced being proportional to the rise in the temperature subject to the limits of safety. The best period for smudging was determined to be between October and December, when the leaves would be well developed and the terminal buds dormant but well formed. The smoke produced at the smudging period drives away the injurious insects which, however, return at a later stage. Smudging was tried at Kodur, but the results were conflicting, from which it is inferred that this treatment cannot always be depended upon to stimulate production.

Crop failure due to diseases and pests

One of the chief reasons of the poor bearing of the mango tree in some years is perhaps the shedding of flowers caused by the hoppers and mildew, so often noticed on mango trees during the blossoming time and specially encouraged by cloudy weather. The hoppers cause physical damage to the flowers when they jump about in large numbers causing them to drop. "The frequent occurrence of the mildew on inflorescences when shedding is going on has been noticed, though the con-

ection of this fungus with shedding itself has not been hitherto emonstrated" (179). This fungus is supposed to develop ı the sugary secretion deposited on the leaves and flowers by ssid hoppers, and further found to be responsible partially r wholly for damaging the crop.

Working on the effect of the hoppers and the mildew found ı mango inflorescences, Wagle (182) states "It may therefore, e taken as proved that the insect can be the cause of the comlete loss of the mango crop." He further states " . . . . . . even xcluding other influences causing loss of fruits, the mildew was apable of completely destroying the crop as occurred in the first nd third flushes of 1925-27, or in the other cases of reducing by ne-third (second flush of 1926-27), or by more than one half 1925-26) in two separate cases." Dealing with the remedial ıeasures tried and found successful in checking these hoppers ıd mildew, Wagle (182) reports that dusting with sulphur is fective both against the hopper as well as the mildew.

ex distribution

It has been recorded (23, 182) that the mango inflorescence ears flowers of three types—the complete, the staminate and the pistillate. Pure pistillate flowers have, however, been found to be practically absent ı sixteen mango varieties studied at Kodur (Madras). It is nly a very small percentage of the complete flowers that set nd develop into mature fruits. The proportion of complete owers in the most important commercial variety of mangoes ı the Konkan (coastal) tract of the State of Bombay, amely, Alphonso, is worked out to be highly variable, from l to fifty-five per cent. produced even in the same flush. he average proportion of these complete flowers was found to e not more than about five per cent. of the total number of owers. Of the small percentage of complete flowers, nearly alf are shed before fertilisation, and almost as much soon after rtilisation. Ultimately, the percentage of flowers which form ature fruits is less than one.

Similar study was undertaken by Popenoe (123) at Florida, Iaheshwari (86) in Northern India and also at the Fruit esearch Station, Kodur (Madras). At the last centre, a udy of 93,305 flowers of 16 different varieties during 1939 ason has shown that, the percentage of perfect flowers was ıe largest in *Neelum* being 16·41 and the least in *Allampur*

Beneshan, being 3·47. *Goa*, *Amlet* and *Khader* come very near to the *Neelum* standard, while *Baneshan*, *Mulgoa* and *Erra Mulgoa* are more or less on a par with *Allampur Baneshan* in this respect. These results considered together with the known performance of varieties seem to indicate that a high percentage of perfect flowers is closely associated with high productivity. Maheshwari has pointed out that the number of flowers in a mango panicle ranges from 1,500 to 4,000. Despite such a large number of flowers, it is rare to come across a panicle bearing more than a maximum of about 10 fruits at the mature stage. A very large number of commercial mango varieties, however, rarely produces more than one ripe fruit per panicle, while a bulk of the inflorescence normally withers away without maturing even a single fruit. Increased set of fruit and better capacity to hold fruits to maturity are, therefore, the two most important objectives that merit the attention of mango investigators. A solution to these problems will considerably assist the evolving of a solution of the allied problem of periodicity of bearing in mangoes, as in several years it has been observed that a heavy crop of blossoms is followed by a very poor yield of fruits, even though the hopper incidence is not severe and heavy rains are absent during the season.

Growth in relation to cropping

The relation between the fruit bud formation and vegetative growth in mangoes was studied in the Philippines at Manilla (52). The materials used for this study were seedling and vegetatively grown *Carabao* mango trees, this variety being the best known there. Both heavy bearing and light bearing trees under similar climatic conditions were studied. Since flowering of the mango trees depends upon the previous year's growth, observations were confined to this portion of the branches only. From the results of biometrical observations, it was found that,

1. "There is a relation between the length and the diameter of the twigs and fruiting. In the case of non-bearing robust trees, there was an abundance of vegetative growth—length and diameter, compared with the bearing trees."
2. "There is a relation between the leaf area and the number of leaves, and fruiting. As the number of

leaves increases each with a less leaf area, the less fruitful the tree becomes, as in the case of the non-bearing robust trees."

3. "In the case of bearing trees, the average length and diameter were greater than those of the non-bearing, but less leaf area."

That a definite relation exists between flower bearing capa-ty of the shoots and their previous growth characters, such as the ·erage length and the number of the new growths produced, as also indicated in a study carried out in the Punjab. It was lso known that the average extension growth as well as the umber of the new growths are markedly greater in shoots that id not flower in the previous year. Biometrical studies were ursued on these lines at Sabour (Bihar) and Kodur (Madras) nder the aegis of the Indian Council of Agricultural Research, nd these too have corroborated the preceding inferences enerally.

Observations made at the Modibag, Poona, show that the ıango shoots should be sufficiently mature for bearing flowers nd that they take about nine months from the time of sprout-ıg to attain the required maturity. The mango trees in-ariably blossom in the cold season, beginning from the nonth of December. In order, therefore, that the shoots may e sufficiently mature by December, they must have sprouted in he preceding March at the latest. It follows that, no shoots hich are put forth in the flushes of the preceding June-July or eptember-October season, can be reasonably expected to lossom in the following December. An attempt was ıerefore made to arrest all new growth which may sprout out uring these two flushing seasons by suppressing growth from uds. The result was that a large number of the older pruned ıoots produced blossom and bore fruits. These observations re not yet conclusive, and have to be further confirmed by ırge scale experiments. Observations at Kodur have, however, evealed that in such varieties as *Neelum* and *Suvarnarekha* even ıe shoots arising in October can produce blossom in the follow-ıg February.

Vegetative growth of trees may also be checked to some extent y artificial methods like ringing, girdling and pruning of the

Growth regulation

roots. Girdling was tried in the Punjab and it was found that it produced a large number of new shoots with a good extension growth, and reduced the extension growth of the first flush shoots. The practice, however, was not found to be feasible for increasing flower production due to the difficulty in rapid healing of wounds. Rough methods of girdling mango trees by making wounds on the bark of the trees with an axe are commonly practised in many parts of India, with the object of making shy bearers productive. No experimental evidence is available for justifying this practice, but from a survey of a few orchards where this system is regularly practised, it appears that the claims made for this method are exaggerated. In any case, the method cannot be relied upon to give good results invariably. The efficacy of root pruning is also doubtful on the mango tree, which does not seem to relish such treatment.

Double-grafting is another process that may perhaps be advocated to force the mango trees bear annually. It consists of grafting a scion of prolific variety on rootstock, and then again grafting the ultimate scion on the graft. Such a process is believed to arrest excessive vegetative growth of the tree making it dwarf, and hastening and regulating bearing. No experimental data on the aspect of double-grafting in regard to mango are available to support this view at present. Double worked plants of four varieties at Kodur have generally produced dwarf trees so far.

Hybridization

As in most other Indian fruits, hybridization work has not been attempted in India towards the improvement of mangoes except at Kodur and Sabour on a small scale. This is to be regretted, especially as there is no dearth of valuable germ plasm amidst the wealth of variations among the cultivated and wild mango varieties and types in this country. Apart from the usually long time factor required for the successful conduct of this kind of work, there is also the handicap before the mango breeder, of a low percentage of fruit set. Out of about 8,000 controlled crosses made with various varieties in Kodur (Madras), hardly 100 developed and reached the final maturity stage. Further work is called for to increase the set. There is no doubt that such lines of work are urgently needed to be undertaken

TOP WORKING OF SEEDLING MANGO TREES WITH GRAFTS RAISED IN THE NURSERY.

Facing page 94.

TOP WORKING OF MANGO BY BUDDING. THE LABELS INDICATE THE POINTS OF BUDDING. *Facing page 9*

on a nationwide basis in India, where there are excellent opportunities for effecting a rich variety of recombined characters. At Kodur, three F[1] hybrids have already been selected as of sufficient merit deserving multiplication, and also some chance seedlings have been adjudged as noteworthy (143).

Top-working of mango trees

Top-working means the renovation of the whole of the top of a tree by inserting scions on the existing branches, so that these scions may grow in place of the old branches of the tree. This method is practised on various fruit trees in several foreign countries including Florida and the Philippines (22,109,125). Top-working by adoption of crown grafting methods necessitates the cutting off of the tree top wholly at one time, and the scions when inserted on the crown are left exposed to the hard conditions of the field. Where the branches are cut one by one and the new sprouts that spring up just below the cut ends, are top-worked to the scions of desirable varieties, by placing the potted grafts over an improvised platform or held in position by some other suitable means, a larger part of the tree is saved and the subsequent growth of scions is afforded greater facilities. When the union takes place, the scions are separated out from the potted graft and allowed to grow on the top of the worked tree. It is necessary to graft several scions in order to top-work a single tree by this method. The purchase and preparation of a large number of grafts, and their care when placed at a considerable height from the ground, until the scions have united with the stock branches, all constitute tedious and expensive items. When the scions establish themselves, they however, need little care. Top-working is a useful method of converting large inferior seedling mango trees into superior types, of hastening their bearing age, and of shortening the period of testing seedling progeny secured by breeding projects, etc. As the rootstock tree is usually well established with an extensive root system, the scions worked on them, grow quickly into vigorous trees and bear fruit early. In Goa and other parts of the coastal tract, side-grafting is practised on fairly old seedling trees raised *in situ*. This tract receives very heavy rainfall during about four months in the year. The annual precipitation concentrated during the months from June to September ranges from 100 to 150 inches. Consequently the atmospheric humidity

is very high. The temperature ranges between 70°F and 100° These factors are all favourable for vegetative growth. Si grafting under such conditions meets with fair success. Crow and whip grafting methods may perhaps also succeed in th tract, but these are rarely practised. Side grafting has a d cided advantage over these two methods, in that the rootsto remains quite intact in case the scion fails to "take" and easi lends itself to regrafting, whereas in crown and whip graftin the rootstock has necessarily to be headed off before the scions a inserted. The best time for grafting mango in the Konkan (coa tal) tract is the months of April, May and June, when all tre start new growth, just before the break of the monsoon.

Growth at this time also gives the scions which "take", th benefit of the following monsoon months to develop themselve In Kaira district seventy per cent. success is said to have bee obtained in side-grafting mango trees.

An interesting method of side or stem grafting of scion to th stem of old tree is successfully practised in South Kanara distri of the Madras Presidency and is known by the popular name ‘insertion.’ Trees having smooth trunks of less than two an half feet in diameter are selected and a triangular patch of bar two inches by two inches is removed on the part intended to b operated upon. Immediately below the lower corners the triangular patch, two slits—two to three inches long—ar made on the bark downwards. Well matured terminal shoo of six inches to eight inches in length and of the previous season growth are selected from the scion parent, defoliated, and in serted carefully within the slip of bark lifted from be ween the longitudinal slits of bark already made, after parin off the lower one and a half to two inches of the scion shoo into the form of a wedge. The triangular piece of bark original removed may or may not be replaced in its former positio The scion is held in position by firmly tying it to the trunk and grafting wax made by melting together three parts of rosin, tw parts of bees wax and one part of cocoanut oil (by weight) applied over the bandaged parts after cooling. Four to s scions are thus inserted all round the tree, and when a larg number of these show signs of active growth, a few main limbs the tree are removed and within about six months, all the top po tions of the rootstock tree are cut off and the wounds besmear

with coal tar, and the tree earthed up close to the lowest scion. The operation of grafting is done during the monsoon from June to December, but many growers are of the opinion that August to December is the best season. Since this method is successfully practised only in places subject to heavy precipitation and high atmospheric humidity, it is doubtful, if it will lend itself for adoption in all the mango growing tracts. It is, of course, a useful method in the coastal regions of Western India from the Malabar coast to the Gujerat districts, where conditions of rainfall and humidity are identical.

Spring budding is also practised in the United States of America on young rootstocks. In top-working old mango trees by this method half or more of the main limbs are cut back to short stubs during the autumn. In the following spring or summer, the sprouts that start from these stubs are budded by first cutting off the shoot squarely a few inches above the base. The bark is then slit downward from the top of the shoots for inserting a shield bud tapered to a thin edge on the side only. The scion is carefully wrapped with a wax cloth and a light coat of melted but cooled paraffin applied over the scion. A paraffin paper bag is then tied over the entire end of the stock so budded.

Top-working can be done by ordinary budding also. The economic advantages of top-working may be gauged from the fact that a tree about thirty years of age worked upon in 1913 began to bear in 1916 and yielded fruits as follows (22):—

	Fruits No.
1916-17	38
1917-18	372
1918-19	450
1919-20	nil
1920-21	200
1921-22	350
1922-23	500
1923-24	450

Mango grafts commence bearing in their fifth or sixth year. Grafts of some varieties have been known in South India to

bear fruit in their third year and a few even in the second ye
Seedlings take a much longer time, although sometimes ev
they are known to commence bearing in their fourth or fi
year. A normal crop may be expected from grafts when th
are about fifteen years of age. Bearing increases with t
advance of age until the trees grow fairly old.

Harvesting of mango fruits

Mango fruits of grafted varieties are usually harvested befo
they are ripe on the tree. The exact time of harvesting is judg
by personal experience, although general
the fruits are supposed to be ready f
harvesting when a few of them fall from t
tree being naturally ripe. There appear to be two reasons f
the harvesting of mango fruits while still green. Firstly, t
fruits improve in sweetness and general quality by storing for
few days after harvesting, and secondly considerable damage
done by insects and birds to them if left on the tree until they a
fully ripe. When fruits are ready for harvesting, they are gen
rally fully developed with their shoulders well formed and the su
face more or less plump. The stage of picking varies co
siderably in different varieties depending upon factors like sligh
yellowing of the rind as in the case of the Alphonso variet
development of a warty surface as in the case of *Cawasji Pat*
and *Pairi*, the appearance of a deep flush as in the case of *Shen*
duria, etc. Whenever possible, it is better to pick fruits wi
about half to one inch of the stalk left on them.

The actual operation of picking is done with a hand too
termed as a mango picker, which consists of a long thin bambo
to the slender end of which is tied a small net bag with a thi
iron or bamboo ring at its open end. The picker is locall
called *vedi*. Two flat iron or bamboo splits are so tied over th
ring that they can easily catch the fruit stalk and break it. Th
fruit falls in the net bag by a slight pull. If the tree is tal
the man who picks has to climb on it to harvest fruits with th
picker and a large collection bag. When three or fou
fruits are collected in the net, they are taken out and put in th
bag. When the bag is thus filled, it is let down by means of
rope and emptied on the ground. The empty bag is then draw
up by the man for collecting a fresh lot of fruits. In the cas
of dwarf trees, climbing on the tree is not necessary and the frui
are picked by hand from the ground.

PICKING AND PACKING OF MANGOES IN THE RATNAGIRI DISTRICT. *Facing page 98.*

An American type of "fruit harvester", which has a clipper attached to the thin end of the bamboo at its base by a spring arrangement, is found very handy. It enables the harvest of fruits with a piece of stalk attached.

Ripening of mango fruits

When mangoes are picked, they are all taken to the store, where they are spread out on a thick bedding of green mango leaves and kept there for about two days. The store is usually a well ventilated place. If the fruits are to be despatched to distant markets for sale, they may be packed soon after harvesting, so that they have time to reach the market before they ripen. For local markets, however, fruit is sent after ripening in the store, that is, when it is almost ready for the table.

For ripening, fruits are spread on rice straw in layers one upon the other, each layer of fruits being separated by a thick padding of straw. Generally, two or more layers are heaped in a single pile and such a pile is locally called an "*Adhi*". It is perhaps preferable to have a single layer of fruit covered completely with a thick layer of straw. The rice straw is soft and does not injure the fruits and, therefore, permits them to retain a good appearance for the market. Other kinds of straw, for example, *Iseilema Wightii*, called "Sona" in Marathi, are also used, but only for inferior mango fruits. The straw bed gives enough warmth for the fruit to ripen, which process in the case of most varieties takes about a week. If the fruits are spread uncovered, the ripening can be delayed considerably to suit market conditions. Ripening in straw beds is considered also necessary to develop attractive colour for the market. The fruits are ordinarily hand graded before they are displayed for sale.

Regarding the keeping quality of mangoes, Burns and Prayag (25) report that in an experiment which they carried out under room temperature, the *Pairi* fruits kept well for about a fortnight, and the Alphonso fruit for about twenty-five days, the fruits losing about twelve to eighteen percent of their original weight during the process of ripening. It is the common experience that the Alphonso keeps well in Bombay for about twenty days and the *Pairi* for eight to ten days. They also mention a trial wherein waxing of the stalk end of the fruit had no effect on the ripening.

Patwardhan (114) who carried out a study of the chemical

changes taking place in the mango fruit during the ripen
process, states "from the temperature record, it can be seen t
as the days proceed, the temperature slowly rises (in the *Ad*
and goes as much as 8°C to 10°C higher than the room tempe
ture. It has been seen that when the temperature goes ab
36°C, mangoes become over-ripe and begin to rot very rapid
When it goes to about 33°C or so, that is, on the fourth day
the *Adhi*, they are removed from the pile and made to rip
slowly, by keeping them uncovered on hay in single layers."

He further states that in the beginning, the change in t
colour, smell and taste is slow, but after the fourth day it is ve
rapid, and may be complete within the next two days or s
It is observed that the amount of acid contained in the differe
varieties of mango is different. It may, however, decrease
about twelve percent of the original raw sample when fruit
ripe, but ordinarily it remains at about twenty-five to thirty-fi
percent of the original sample. The sugars increase rapidly i
the beginning of the ripening process, the increase being gradu
later on. Non-reducing sugars increase from 50 to 65 percen
while reducing sugars from 1 to 5 percent only. It is clear tha
when the juice is preserved in cans there is very large increase o
the reducing sugars, owing to the likely inversion taking place.

There are four distinct stages of the maturity of mangoes
that is the juvenile stage, the adolescent stage, the climacteri

Ontogenetic stages of maturity of mangoes

stage and senescent stage. The juvenile stage i
the period from fertilisation for about twenty
one days. It is marked by a rapid cellula
growth, high respiratory activity and high
water content. The C/N (carbohydrate: nitrogen) ratio is low
The adolescent stage is the period between twenty-one and
forty-nine days. It is marked by the maximum growth, deve-
lopment of aroma, and medium respiration. The C/N ratio
increases. The climacteric stage is the period between forty-
nine and seventy-seven days and is a critical stage. Respiratory
activity is slow, and sucrose is medium. The C/N ratio is high.
The senescent stage is the period from seventy-seven days
onwards. The rate of respiration increases with an abrupt
decline in sucrose and increase in glucose. The C/N ratio
goes very high.

The system of marketing these fruits in the Bombay Presi-

dency, and in fact, all over India, has been very unsatisfactory.

Marketing of mango fruits

The result is that considerable loss occurs by spoilage due to bad handling and defective grading and packing. Enquiries made by the Mango Marketing Committee appointed by the Government of Bombay, in 1925, led to investigations and devising of certain practical measures towards improving the situation, and valuable results are now noticed in this regard (138). The course taken by mangoes from the grower's field to the consumer's table as it happens at present is interesting. A study of this course shows the following stages of preparation and progress:—

1. Picking and packing.
2. Journey by road to the railway station or to the port wharf (*bunder*).
3. Journey by railway or steamer.
4. Journey from railhead or wharf to the market at the market end.
5. Display and grading at the market.
6. Disposal—wholesale and retail.

Not infrequently, the grower sells his crop standing on the trees to local contractors called *Bagwans*, who are then responsible for the picking, packing and despatch of the produce. Whenever the sale of standing crop does not take place, the grower sends his fruit to the market himself. In both cases, however, the picking operation does not receive much attention. Mature and immature fruits are often picked together and physical injury to them is not uncommon. While packing, hardly any grading or sizing is done; what little sorting is done, is designed to place the best few fruits on the top of the package. Small fruits are placed at the bottom, medium at the centre and large at the top. All these sizes get usually mingled up when the packages are opened and emptied in the market. The most common containers are bamboo baskets which are flexible and fragile and liable to serious damage in transit besides being very inconvenient for handling and storage. In some progressive tracts, as in the case of the Ratnagiri mangoes these baskets are gradually giving place to wooden crates. The majority of mangoes are, however, still being packed in bamboo baskets of varying

sizes and shapes and are subject to considerable damage a loss during transit. The handling of the packages while loadi stacking, and unloading in carts, railway trains and stean holds, is rough and crude. On arrival at the market, the co mission agent to whom the parcels are consigned, oft plays the jobber, opens several packages, sorts the whole according to the market requirement and sells the different l to different classes of retailers and hawkers. Very often t wholesale transactions take place under cover, by taking bids offers under cover of a piece of cloth so that none except the bu who makes the bids and the commission agent can have an id of the price offered and accepted. Open auction sale is a ra exception. After the wholesale transaction is over, the comm sion agent prepares his account for the consignor, and sen him the balance of the price realised after deducting his ow commission charges and other market expenses. These expens are divided under several heads, including ground rent an charity charges, and almost each head leaves ample room to th commission agent to swell his own net income. The consign in the village has to content himself with whatever is sent to hi by the agent, who happens to be the sole representative at th distant market. Retailing at the market is in the hands of sta holders, street corner shops and hawkers. Often the wholesal is also the commission agent and *vice versa* and may also have h interests in the retail trade. Such is the complexity of the dis tributing organisation of fruits in this country. The situation rendered still worse to the detriment of the grower b the absence of proper transport and storage facilities as we as a system of check to prevent deceitful practices.

Investigations in the marketing of fruits

Realising the chaotic situation in agricultural marketing the Royal Commission on Agriculture in India (1929) observed "We have sought to make plain the exten to which the prosperity of the cultivator an his progress in agricultural efficiency depend upon sound marketing. It has been pointed out that compara tively little has been done by Government in India to assis the cultivator in his marketing operation." In so far as man goes are concerned, the first enquiry of its kind was conducte by the Mango Marketing Committee appointed by the Govern ment of Bombay in 1925. The investigations of this Com

ittee were confined to the system of marketing mango in the onkan districts of Kanara, Ratnagiri, Kolaba and Thana om where this fruit is chiefly shipped to Bombay. The Committee made a number of recommendations but the progress implementing these recommendations was extremely slow. ater on, the Bombay Government appointed the Bombay ruit and Vegetable Market Committee in 1933 to go into the ıller details of the problem. The Committee's report conaining a very large number of practical suggestions for improvement, was published in 1934. An enquiry on the ıarketing of fruits, particularly mangoes, was also carried out Bihar in the year 1935. Later on, in co-operation with he Provincial and State Marketing Officers, the Agricultural Iarketing Adviser to the Government of India conducted a etailed all-India survey on the marketing of mangoes but the esults of the survey have not yet been published.

rowers' rganisations

These various enquiries and the published reports depict the eplorable and wasteful conditions of the system of marketing the mango fruits. It is, however, to be noted with satisfaction that on the strength of the recommendations of the Bombay Fruit and 'egetable Market Committee, the Government of Bombay ave now appointed a Provincial Fruit and Vegetable Market ommittee, practically on a permanent basis, to watch and uide the trade in the Province. Side by side with these sporadic udies, gradually circumscribing the conditions prevalent in ıost of the Indian Provinces, attempts to organise the growers re also being made. One of the chief factors which adversely ffects the prosperity of the growers at present is the lack of -operation and organisation among themselves. Primarily due the ignorance of the growers and to the lack of a definite ational policy in developing the fruit industry, the growers are arrying on their enterprise in a disconnected and individualistic ıanner. They have not yet been able to realise the benefits of oncerted action. The Imperial Economic Committee ppointed by His Majesty's Government in England observe in ıeir report on the marketing and preparing for the market of uit, "We are convinced that the whole tendency to closer orgaisation of fruit growers is desirable and indeed inevitable, and we ould give general emphatic support to the principle of their

organisation in the overseas parts of the Empire. As an in
vidual, he (the grower) is helpless against the great chain of or
nisations with which he has to deal with in the transport of
fruits by land and sea, the railway and shipping companies, a
the marketing organisations which exist in the United Kingdon
The co-operative movement in India has rightly to be credi
with the origin of the agricultural produce sales societies such
cotton and gur sale societies in various centres. The man
sale societies in the Ratnagiri and Dharwar districts are a
working on co-operative lines. These societies have had co
siderable educative influence on the disorganised and illitera
peasants of the countryside and have gone a long way to impr
on them the benefits of concerted action. Lately, provinc
fruit growers' associations have sprung up in Bombay, the Utt
Pradesh, Madras and the Punjab, with a view to work for t
betterment of the growers in these provinces. While the ai
and objects of these bodies are varying to some extent, a
though they are in infancy as yet, the problems they have almo
invariably taken up to solve are those relating to the marketi
of growers' produce. One and all have realised through bitt
experience that the improvement of the economic condition
the growers depends upon a better system of the disposal of the
produce based on more favourable transport facilities couple
with a more efficient and widespread distributing organisation

Grading of mangoes

It has already been stated that ordinarily mangoes, lil
most other fruits, are packed in fragile bamboo baskets withou
proper grading except "topping" the bask
with large fruits, and placing smaller an
inferior ones at the bottom. This practice has naturally de
troyed the confidence of the consumers. Combined with roug
handling during transit, the prevalent practices have brough
down the price of the pack very considerably. The investigation
carried out by the Bombay Department of Agriculture, publishe
in their leaflet No. I of 1931, have shown that if mangoes of th
Alphonso variety are graded carefully according to suitabl
standards, before packing for the market, a net gain as a resu
of grading fruits alone over the ungraded lots is on an averag
Rs. 21-8-0 per 1000 fruits, after deducting all extra charge
involved in the grading operation. The three grades foun
suitable for certain varieties are:—

1st *grade* with fruits, weighing 28 tolas and above,
2nd *grade* with fruits weighing 24-28 tolas and
3rd *grade* with fruits weighing 18-24 tolas.

The average proportion of fruits of these three grades in an ordinary mixed lot works out at 150, 450 and 400 respectively, and each grade by itself brings a much higher price than the immediate lower one. This fact has been appreciated by the growers and consignors who are now taking up the grading of fruit rapidly in their commercial practice with evident advantage. An act to provide for the grading and marketing of mangoes known as Agricultural Produce (Grading and Marketing) Act, No. I, 1937 was passed by the Government.

Packing of mango fruits

Until lately, the fragile bamboo baskets have been shown to be a source of frequent loss on long journeys due to unsatisfactory handling. It is also insecure. To find out the efficacy of bamboo baskets as compared with suitable wooden crates or boxes, an attempt was made to send actual consignments in both types of containers from Ratnagiri to Bombay. These showed that:—

1. The average loss due to damage and pilfering came to 3·9 percent of fruits packed inboxes, while in baskets it came to 16·1 percent. Thus the loss in the case of baskets was five times greater than it was four in the boxes.

2. The average gain in price per 100 fruits in wooden containers over the same number in bamboo baskets varied from Rs. 2-10-0 to Rs. 6-4-0 according to the price fluctuations in the market.

3. A wooden case can be used at least four times in the season, while the basket is used only once.

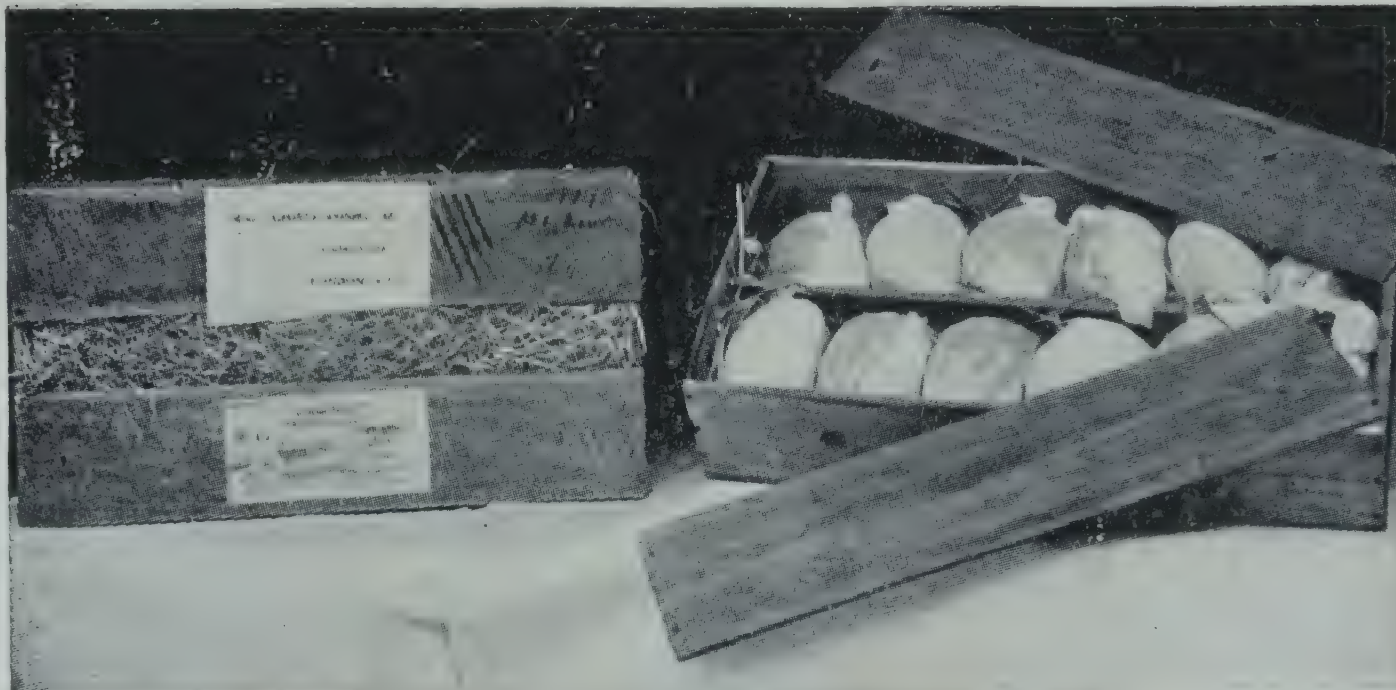
The cost to get back the empty cases from Bombay to Ratnagiri, a distance of about 120 miles by sea, is of course fairly great. But even then, packing in boxes would pay under items 1 and 2. Experience shows that the proper thickness of the pieces used for boxes is half an inch and their dimensions externally 20 inches and 15 inches. The capacity of such a box would be to hold 100 to 115 Alphonso fruits. The holes for

ventilation made on two sides of the case are half an inch diameter. Coir rope handles are fixed on two sides for ea handling, and hinges are fixed to the lids. The boxes are fa tened by wire and sealed with a plier. The total weight of t box after full packing should not exceed eighty pounds for ea handling. The chief difficuly in adopting packing improv ments for general use is that, suitable wood for making packin cases is not cheaply available and that, until such cases can manufactured on a mass scale they would not be cheap. Th transport companies also should show material concessio by carrying back empties at a nominal rate in the larger intere of the trade. At present, a light type of wood, namely, *Saya* (*Bombax Malabaricum*), is being used for this purpose, and few private concerns have taken to manufacturing the cases i the Ratnagiri district. It will, however, take some time befor the boxes come into general use.

In Florida, a patented crate resembling a modified type o the box used for oranges and with a central compartment holdin ice, is reported to be used by some people to guard agains losses in long distance transports. Wardlaw and Leonard (184 consider that a standard twenty pound tomato box (5 by 16½ b 17 inches) packed in one or two layers, will be suitable for man goes. Smith (161) on the other hand, suggests two sizes 17 by 11½ by 5½ inches, and 17½ by 11½ by 4½ inches. The frui sizes of cultivated varieties in India are so varying that th optimum size of package for each variety has still to be worke out.

From the Madras State, very large consignments o *Bangalora* (syn. *Totapuri* or *Collector*) are loaded in wagons an sent without any packing to Calcutta, Hyderabad (Deccan) and the Bombay Presidency. These fruits stand considerabl careless handling and are good shippers and, therefore, they ca stand such transport to an extent. But it will mean a great los to the growers as well as consumers if attempts are made to sen other delicate and superior varieties by this method.

After a long period of preliminary trials carried on i Bombay on the keeping quality of mangoes, an attempt was mad in the years 1932 and 1933 (27) to export this fruit to Europ with a view to expand the market for it. The Alphonso or th Bombay mango was selected for this export, because of its attrac-



PACKING OF BOMBAY MANGOES FOR EXPORT BY STEAMER JOURNEY.

Facing page 106.

PACKING OF BIHAR MANGOES FOR EXPORT BY AIR.
(*Courtesy* : A. Aziz, Esq., Ex-Minister For Agriculture, Bihar and Orissa.)

Facing page 107.

Export of mangoes to Europe

tive appearance, medium size, fibreless pulp of good taste and consistency, high quality and reputation of keeping well even under ordinary conditions of temperature. This variety is also cultivated on a fairly large scale, and hence it is available in large quantities for the export trade. Great care was taken to pick the fruit at the right stage of maturity, namely, when it is about a week earlier than the usual picking time for local marketing, in order that the fruit might stand a long journey. This stage of maturity is now standardized and called the 'B' stage. The preparation of this fruit for export consisted of grading it in two classes—"Commercial I" and "Commercial II" with fruits weighing from 24 to 28 tolas and 20 to 24 tolas each respectively. These fruits were then packed in specially designed trays of light wood admitting free aeration. The fruits were wrapped in tissue paper and placed in two single layers at the rate of one dozen per tray. Five such trays were tied together to make a package for convenience of handling in transit. These packages were stowed in the "Pursers" cool room at a temperature of about 45°F, where they were observed to keep well for over three weeks. The packages were also properly labelled and consigned to the agents in England. Before stowing on board the steamers, intimation of the despatch of the consignment was given to the consignees in time. As a result, it was observed that the fruit can reach England, a journey of nearly three weeks, in very good condition, provided the temperature in storage did not vary much. The fruit also found ready market, but only when supplied in small quantities in England. The price fetched was on an average nine annas and six pies per fruit as against the total cost of exporting which came to five annas and six pies only per fruit. This showed bright commercial prospects in the year 1932. But when the consignments exceeded the market requirements in bulk in the year 1933, there was considerable despair and loss owing to the market being glutted. The result was that the price fetched per fruit fell very low, while the cost of export remained almost constant. Moreover, the difficulty of finding enough cold store space in the steamer holds also cropped up. The present situation is that, until these difficulties are overcome the export trade in this fruit has necessarily to progress very cautiously.

Cold storage of mangoes

The storage of mangoes attracted the attention of worke in this country, more than a decade ago. Small lots of the A phonso variety were stored for trial at variou temperatures in a cold chamber in Bomba and the result was found to be encouragin (28). The fruit kept well for over a month at a temperatu of about 40°F in the preliminary trials, where the contr of a proper temperature was difficult as the chambers coul not be exclusively reserved for this work. However, in the in terest of the trade, it was found necessary to work out the exa keeping quality and the optimum temperature required fo each of the more important commercial varieties of mangoes i India, including the Alphonso. With the help of the financ made available by the Indian Council of Agricultural Research it was possible to work on this problem and several varieties wer tested at the cold storage station, Ganeshkhind, Poona. Ou of the several varieties tested for their commercial storage quali ties the Alphonso was found to keep for fifty to sixty days a 48°F, when picked at the 'B' stage of maturity. The varietie tested among others were the *Suvarnarekha*, Alphonso and *Pair* The results already obtained with the Alphonso mango wer confirmed and the influence of local conditions of soil, climate cultivation, etc., on the storage quality of the fruit produced wa also determined. The successful development of the expor trade of India in mangoes should be fostered as a result of thes experiments.

Gas storage of mangoes

The technique of gas storage, using chiefly carbon dioxid has been developed to a great extent in England and elsewhere In India, trials on the gas storage of mangoe was undertaken along with the cold storag trials at the Ganeshkhind Fruit Experimen Station, Poona. The results were not very encouraging.

Chemical analysis

Six important varieties of mangoes were analysed in Jav (30). The average weight of fruit and the percentage of pul are compared with those of the foreign man- goes, which possess a weight of 350 grammes and 70 percent or more of which is pulp. Along with finding the chemical analysis of the fruit, the skin of the mango wa also analysed. Javanese mangoes contain as much crude fibr as is contained in the Alphonso. These varieties equal Alphons

Nutritive value of Indian mangoes

NAME	Moisture %.	Protein %.	Fat (Ether Extractives) %.	Mineral matter %.	Fibre %.	Carbohydrate %.	Calcium (Ca) %.	Phosphorus (P)%.	Iron (Fe) mgs. %.	Calorific value per 100 gms.	Carotene (International units per 100 gms.). Vit. A.	Vitamin B_1 (i. u. per 100 gms.).	Vitamin C mgs. per 100 gms.	Calories per ounce.
Mango, green	90·0	0·7	0·1	0·4	..	8·8	0·01	0·02	4-5	39	150	..	3	11
Mango, ripe	86·1	0·6	0·1	0·3	1·1	11·8	0·01	0·02	0·3	50	4800	..	13	14
Mango, Kala Ishad Ankola	85·9	1·0	0·1	0·5	..	12·5	0·01	0·02	0·5	55	1860	..	24	16

in regard to total sugar (13·1 to 16·8%) and sucrose (9·7 12·8%).

Mineral constituents

Determinations by Chace in the pulp French and Filipino mangoes and a thi variety not specified show 0·53, 0·41 and 0·78 percent ash. Analysis of the ash appears below:—

	K_2O	CaO	MgO	P_2O_5	SO_3	SiO_2	Cl
	%	%	%	%	%	%	%
French	47·37	6·38	1·62	6·49	3·67	—	3·88
Filipino	51·79	1·74	3·25	9·04	4·88	1·75	1·56
Var. unknown	49·37	2·38	—	5·57	3·84	2·14	4·20

Mangoes have a high sugar content. They are rich in vit mins. The amounts of vitamin A and C apparently vary a gre deal in the different strains. The deep yellow colour of th flesh of the Manila fruit suggests a rich A content. Crawfo and Perry (34) found one variety as high as good butter, oth varieties showed about half this value. They examined vitami C potency and found values in different species varying fro nothing up to twice the content of lemon.

Mitra and his co-workers (94) found mango (Aam Bomba to contain 6.0 mg. Carotene and 10.5 mg. ascorbic acid p 100 gm.

Daniel and Munsell found ascorbic acid content of mang as per table given on page 111 :—

Ascorbic acid content

(Table on page 111)

(Values expressed as milligrams per 100 grammes)

Besides being a very delicious fruit, rightly called the kin of fruits, mango has a high nutritional value. It is rich i

Food value

Vitamins A and C. The pulp of the Alphons variety is one of the most potent sources o Vitamin C. It is reported by Perry and Zilva (116) to b

Food	Description	Quantity of ascorbic acid: Dye method	Quantity of ascorbic acid: Iodine method	Year reported	Investigator
Mango (*Mangifera indica*)	Pulp	13	..	1935	Ahmad (2)
	Pulp, different graft from above	15·3	..		
	Green	3·2	..		
	Green, Bengali Deshi variety, Kancha	5	9·7	1935	Ghosh and Guha (54)
	Ripe, Bengali Deshi variety, Paka	2	4·4		
	Ripe, Fazli variety	34	44	1935	Ranganathan (134)
	Ripe, Langra variety ..	69	88		
	Green, very tender, pickled in salt	176·5	..		
	Dried, pickled in salt ..	2·6	..		

Average composition of the edible flesh of mango according to Winton and Winton (191) is as below:—

	Solids Total %	Solids Insol. %	Protein	Acid % (citric)	Invert Sugar %	Sucrose %	Ash Total %	Ash Alk.* %
Mango ..	16·76	1·76	0·43	0·39	3·56	10·06	0·47	47

*Ml. 0·1 N acid per 100 gm. fruit

According to Sherman (157) the average composition of fresh fruit is as follows:—

As purchased	Edible portion						
						Fuel value	
Refuse	Water	Protein	Fat	Carbo-hydrate including Fibre	Ash	per 100 grammes	per pound
%	%	%	%	%	%	Cals.	Cals.
34	81·4	0·7	0·2	17·2	0·48	73	335

HOME CANNING OF MANGO: ESSENTIAL EQUIPMENT.

(*Courtesy* : S. N. Venkatraman.)

Facing page 113.

much richer in vitamins A and C than many fruits normally considered good sources of these vitamins. The *Cawasjee Patel* variety although slightly less active, is as potent as the previously known natural antiscorbutic source. The *Shendrya* variety contains comparatively smaller amounts of vitamin C. The pulp of all three varieties contains vitamin A in quantities similar to those possessed by butter. The Alphonso variety is somewhat better than the other two varieties in this respect. Further trials did not indicate any significant results as to whether the maturity factor had any bearing on the vitamin content of the mango. Guha and Chakravarty (59) have also found that Indian mangoes are a fair source of Vitamins B and C, and a good source of G (B2). Mangoes possess a high sugar content, but they are poor in calcium, phosphorous and iron. This fruit, therefore, deserves to be very highly valued and should have a great future in the world market.

The composition of the edible fruit flesh of mango grown in West Indies is well illustrated by 4 analyses made by Cousins and 9 analyses made by Chace, Tolman and Munson. Pratt and Del Rosario made 3 analyses, of fruit grown in Philippines, and Thompson, 8 analyses of fruit grown in Hawaii. Results are given on page 114.

Canning of mango

The mango crop is in season for about two months only in the Bombay Presidency, during which period the fruits glut the market considerably. The growers do not realise a proper price for their crop and a good deal of waste occurs. Considering that this is practically a monopoly produce of this country, there is no reason why it cannot be packed in cans for marketing even to distant countries. The possibilities of developing the mango canning industry have been explored by some. Private organised effort is, however, necessary to place this line of work on a sound footing.

It is chiefly the superior table varieties of mango, which are used at present for canning. Factories in the North Kanara district use the *Kala Ishad* mango for this purpose. This variety is a very poor keeper, though of very high quality and is therefore most suited for the canning of mango pulp. In Ratnagiri and Bombay the Alphonso fruit is used for canning. The *Pairi* fruit has a pulp of soft consistency and may also lend itself to canning. But the most appreciated canning variety in the

Average composition of mango flesh

	Flesh in fruit	Solids, Total	Solids Insol.	Protein	Fat	Acids as citric	Sugars reducing	Sucrose	Fibre	Ash total	Ash Alk.
	%	%	%	%	%	%	%	%	%	%	CC.
Cousins											
Aver.	58	18·80	1·02	..	..	1·44	3·72	8·81	..	0·32	..
Chace, Tolman and Munsom											
Aver.	63	16·76	1·76	0·43	..	0·39	3·56	10·06	..	0·47	47
Pratt & Del Rosario											
Aver.	69	22·30	4·50	0·73	..	0·27	3·27	12·60	..	0·46	55
Thompson											
Aver.	64	20·07	3·44	0·71	0·15	0·42	3·16	12·09	0·59	0·39	..

Bombay Presidency is the Alphonso which can be sliced and canned in syrup.

Canning of mangoes is not difficult even on a home scale. The process consists of extracting the pulp of the variety selected, removing the skin and stone. As yet no efficient mechanism has been devised for extraction of pulp and stone. The pulp is then filled into sterilised and preferably lacquered cans, upto about half an inch from the brim. The lid is then placed on the filled can and is partially seamed with a hand or power machine. Cans so closed are then made to stand in a water bath, taking care to see that no water enters them or splashes inside. It is also possible to drive out the air from unseamed cans. The water is kept boiling for about seven to ten minutes, and when the free as well as dissolved air inside the cans is driven out by the heat produced in them, the cans are taken out of the bath and finally seamed air-tight when still hot. They are then placed in the water bath once again, this time immersing the cans completely in water, which is boiled for about thirty minutes depending upon the size of the can. The first heating is called the process of "exhausting", because at that time all the air inside the cans is driven out, and the cans are exhausted. The second heating is called the process of "sterilising" or "processing" because the contents of the cans are sterilised by killing all the harmful organisms in them, which if retained would bring about the spoilage of the cans. After sterilisation the cans are immediately "chilled" by throwing them in cold water, so as to prevent over-cooking of the contents. The cans on cooling are stored in a cool place until they are required for sale or despatch to another place.

At Kodur in the Madras Presidency, it has been found that exhausting need not be done for more than ten minutes, but in this case the lid is not placed over filled cans. The lids are seamed soon after ten minutes exhaustion, and processed for twenty minutes, and subsequently chilled in water. Canned mango pulp and slices, subjected to these treatments, have preserved their natural aroma and flavour of the fresh fruits to a very great extent, and on bacteriological analysis after six months storage showed no trace of any harmful organisms. Since the quality including the value varies markedly in different varieties of mangoes, a uniform procedure to be

adopted in the canning of each of the several well-known Indi varieties has yet to be worked out to effect standardization the ultimate product.

The preliminary trials on the suitability of a number mango varieties have, however, shown that for the produ tion of best canned mango pulp, a variety should be slight juicy, should possess a strong and pleasant aroma, brig coloured pulp, and be free from stringiness. Some of the see ling types of mango, though valueless as table fruits, because small size and big stones, were found to be very suitable for th purpose at Kodur.

In the case of mango slices, the fruit is peeled and two bro slices are taken from the two flat sides of the fruit while tv narrow slices are taken from its narrow sides. These slices fro one or more fruits are filled in neatly into the cans. Sugar syru of the strength of 25-27 percent, is poured into the cans to f in all the interspaces of the slices up to about half an inch fro the brim of the cans. The cans are then subjected to exhaustio and sterilisation as above. They are then stored away in suitable place.

It may be advantageous to can only slices of uniform sha and size to produce cans of graded quality, and for th purpose to separate the slices from flat sides from those obtain from narrow sides of fruits. The latter may be canned as pi The mixed slices, however, lend themselves for canning as fru salads. An attractive and delicious salad would be a mi ture containing mango, papaya and pineapple.

Grafted varieties of mangoes like *Langra*, *Safaida*, *Banesha* *Sandhuri*, *Dusheri*, *Saroli*, etc., may all be preserved com mercially in the form of canned slices, which represent th nearest approach to the fresh fruit and can thus be made availab during the off season. The stage of ripeness of the fruit when is used for the purpose is, when it is just firm ripe, *i.e.*, neither t hard nor too soft—the actual canning stage being determined trials and experience. One of the recommended commerci methods is to wash the fruit and peel it with a stainless steel peeli knife and cut into slices of the desired thickness which may th be immersed in cold two percent common salt solution. T slices are rinsed in cold water and packed in lacquered ca Hot syrup of 35° Brix (prepared by adding 5·4 lb. of sugar

SLICING OF RAW MANGO FRUITS FOR SALTING.

Facing page 117.

gallon of water) is added to fill the inter-space and then exhausted water for 12 minutes, followed by immediate cooling in running cold water, after which the cans may be stored in a dry place.

Various other preserves of mango can be prepared with advantage using fruits at all stages of maturity. Pickle, chutney, jam, sweets of different kinds, drinks and dried mango pulp or mango leather are common in this country. Mango sauce and mango butter are some others among the vast variety of products that can be usefully made out of the raw and ripe fruits. Mango chutney, pickle and dried pulp are being prepared in several parts of this country as a cottage industry by various methods to suit individual taste.

Salting of mango

Salting of mangoes is chiefly done at *Rajapur* in the Ratnagiri district. Raw fruits of seedling trees are used for this purpose. Fruits are peeled, cut into small slices salted and packed into wooden barrels. The stones are thrown away. The peeling and slicing are done by women and children on contract labour. The barrels are sent to Bombay by small boats called *Machawas*. Each barrel contains five hundred-weight of slices. The slices are used for preparing chutney or *achars* (pickles). Similarly, large trade in brined mango slices exists in West Bengal and U. P. also.

Whole fruits of mango are also preserved in brine for use out of season. This is generally done in small quantities in earthen pots or wooden casks—either fresh or after being half boiled, the medium of preservation being about 15 percent strong brine. Such fruits last for some months.

Dried mango pulp, sometimes known as "mango sheets" is a favourite product prepared in many parts of the country. One of the methods of preparing this product is as explained below. The clean and thoroughly washed fruit of the juicy variety—fully ripe with thick scarlet yellow pulp—is squeezed either with gloved hands or through a pulping machine followed by screening through a stainless steel sieve. The screened pulp is then spread in many thin layers on trays $2\frac{3}{4}' \times 2'$ covered with sheets of buttered glazed paper. The trays are then put in the sun for drying or for large scale production they are put in the dome-drier at 140°—150°F. The first layer of the juice having been dried, it is lubricated and another layer made thereon for

drying in the same manner. The process is repeated until sufficiently thick layer ($\frac{1}{4}''$—$\frac{1}{2}''$) of the dried pulp is obtaine By exposing the product to sulphur dioxide fumes for 12-2 hours, the product can be made to retain the attractive golde colour and appearance for a considerable period without deteri ration in quality.

Diseases and pests of mango

The mango tree suffers from several diseases and pests i Western India. Two among them seem to be more serious tha others as they considerably reduce the yiel One is a pest, a mango hopper and the othe is a disease, known as powdery mildew. Cloud weather encourages their incidence of attack as well as th damage by them. The mango tree usually flowers in the Bomba Presidency in three flushes—the first appearing in November December, the second in January and the third in February The first flush is generally almost free from both the hoppers an the mildew. The second flush which appears in January an which is the heaviest of all is affected badly by the hoppers an to a slight extent by the mildew, whereas in the third flush th hopper attack diminishes but the mildew gets worse.

Mango hoppers

The hopper is a small wedge-shaped insect, belongin to the class of bugs (182). As soon as the blossoms appear these tiny insects lay their eggs inside the bud The eggs hatch in 4 to 6 days. The smal wingless nymph, which emerges from the eggs sucks th sap from the flowers and tender fruits and develops into winge adults in ten to twelve days after casting four moults. Th continuous drain of the sap by the nymphs and the adults lead to the premature dropping of the flowers and young fruits. Besides, these insects secrete large quantities of "honey dew" which cover the flowers and thus interfere with their development. The characteristic blackness of the flower buds an leaves in the affected gardens is due to the development of a black sooty mould on the sugary secretion. The winged adult are found resting on the shoots and leaves, and when disturbed they jump and fly to neighbouring leaves causing a peculia spattering noise, particularly when the attack is severe. Th hoppers may destroy the entire crop, but usually the loss varie from 25% to 60%.

There are three species of hoppers, namely, *Idiocerus clypeali*

DUSTING MANGO TREES WITH SULPHUR AGAINST HOPPE
AND MILDEW ON INFLORESCENCES. *Facing pa*

. *atkinsoni* and *I. niveosparsus*. Of these, the first is the most harm-ıl and smallest in size. Uppal and Wagle (175) have described he life history and distribution of all the three species in the Bombay Province. Their nymphs suck sap from flower buds and lowers and cause severe damage. Dusting the inflorescence vith sulphur of 300-mesh and then repeating the application .t ten days' intervals gives satisfactory control. In Konkan nd Karnatak where the sulphur-susceptible *I. clypealis* is pre-valent, 3 to 4 applications will give effective control while 8 to 0 dustings may be required to control *I. niveosparsus* in South Gujerat and Bombay suburban area. Recently Trehan (172) ound that dusting with 10% D.D.T. plus sulphur in the atio of 1: 1 yielded very satisfactory control of this pest in the Bombay Province. Deshpande and Karandikar (41) state that praying of a contact insecticide like the fish oil rosin soap (1 lb. of fish oil rosin soap to 4 gls. of water) controls the pest in the nymphal stage, but has very little effect on the adult. Trehan (172), however, noted that spraying with 0·2% D.D.T. proved very effective and economical.

Powdery mildew

Powdery mildew due to Oidium mangiferae is easily distinguished by a whitish coating on the affected blossoms, which appear as if dusted with white fine powder. The mildew makes its first appear-ance on the scales, fruits, buds of tender flower-heads, axils and stalks. The minute spores of the fungus are carried away by wind from the affected, flower-heads to the hairy unopened flowers, which thus become diseased. A fresh crop of spores s produced within five days from the time of infection. The rocess of spore formation and secondary spread continues as ong as conditions are favourable. It can thus be seen how a ew affected flowers and leaves can cause widespread epidemics nder favourable conditions. The white appearance of the iseased blossoms is due to the fungus. The fungus feeds on the uter cell of flowers and very young fruits, which subsequently ry and drop down. Powdery mildew, though not as destruc-ive as the hoppers, may cause a loss ranging from five to wenty percent, mostly during the months of February and March.

Sulphur dusting is the cheapest and most effective remedy gainst both the hoppers and mildew, as a deterrent against

the former and a preventive and curative against the latter b its residual effect is not much. In a bad case of hopper infectio however, it is more advisable to either spray with D.D.T. or du with D.D.T.+sulphur or gammexene+sulphur which ha a good residual effect as well as very high percentage of imm diate knockdown. These treatments keep the insects away f a considerable period and only a few dustings are needed. should, however, be noted that sulphur dust should invariab be 250-300 mesh fine as coarse sulphur has little fungicidal valu Dusting is best applied by the Peerless Dust Gun, which wor well for trees 12-15 ft. in height. For taller trees, however, t use of a step ladder or extension tubes is found convenient.

The number of times it is necessary to dust sulphur w depend upon the season and the source of infection. How ever, in the coastal tracts, the following schedule of dusting h given the best results:—

1. The first application should be made soon aft flowering. It is by far the most important as it preventive against both the pest and the diseas and should, therefore, be done very thoroughly.
2. The second application should be made about 15 day after the first and may be followed by a thir application. Care should be taken that a thoroug application of the dust is made in each case.

By mixing D. D. T. or gammexene to sulphur, the interva may be increased and the number of dustings reduced. Th application may be repeated soon after the treatment if rain fal and washes the dust.

Dusting should be preferably done in the mornings whe the wind is not strong because high winds result in waste o material, while a gentle breeze helps the operation. Still day are the best.

On an average 1-3 lb. of material may be enough for eac dusting per tree. The cost of dusting sulphur including labou comes to about one rupee but its mixture with D. D .T or gammexene proves more effective though slightly more expen sive.

While dusting sulphur or any mixture, the operator shoul work with his back to the wind because these insecticides caus

ritation to the eyes which should preferably be protected by oggles. If the eyes become inflamed, immediate relief may be otained by washing them in a solution prepared by mixing a aspoonful of soda bicarbonate (baking soda) in a large glass of ater.

:em borer

The stem borer (*Batocera rubus*) is a very common and rious pest of mango trees. The borer is a stout beetle grub which bores into the stem or a branch of the tree. Eggs are laid in chinks of the older ırks and the grubs hatching bore into the stem and their presence n be noted by the frass coming out of the hole. The grub n be extracted by means of a thin hooked wire passed inle the gallery. If this is not possible, a small cotton plug pped in carbon bisulphide, petrol or chloroform or a crystal of otassium cyanide can be inserted into the gallery and the mouth osed immediately with mud. Preferably, all the openings on tree should be closed so that the grub feeding inside is suffoted to death by the vapours of the chemical used. All the ees in the garden should be treated together, and all the holes ı the same tree should be inspected and treated as above. the gallery is shallow, it can be opened and the grub scooped ıt without much difficulty. The injury caused to the trees in ese operations, should be treated by painting it with coaltar.

Another borer—*Chlumetia transversa* is a major pest feeding side the young growing shoots. In the rainy season young afted seedlings are severely damaged and may even be netted. ıe tunnelled tender shoots drop off and dry at the end. Cutg the twigs below the tunnel and burning them reduces the ack in the next flush. Spraying with 0·5 percent lead enate at 3-4 days intervals on new shoots checks the attack ısiderably.

af eating insects

Several types of caterpillars and other insects eat the tender ves and shoots of young nursery plants. The greatest setback is received by the seedlings when their leaves are eaten away or cut by insects and drop n after new sprouting. Occasional spraying with lead arsee checks the ravages of these insects, and the young dlings, are found to thrive better when thus treated. In ylon the young trees in the orchards are also subject to mage by weevils which attack young leaves. To control this

pest spraying with lead arsenate at the rate of one ounce three gallons of water is recommended.

Another common pest is the fruit weevil, *Cryptorhyn mangiferae*. The weevil is about $\frac{1}{3}''$ long, dark grey in colou with darkish bands on *elytra*. The eg are laid in the undeveloped ovary of a fru and the grubs bore into the stone where they mature. Wh the fruit is ripe, the weevil usually comes out of the stone a spoils the pulp. Some varieties of mangoes are particula favoured. By way of remedial measures the affected fruits a stones should be burnt and the soil around the affected tr should be dug out to expose the weevils.

Mango stone weevil

Some mango fruits which appear quite sound from outsi are found infested with maggots. The fruit-fly lays eggs well-developed fruits, and the maggots sp all the pulp. When full grown, they co out of the fruit and pupate in the soil. Four different speci namely, *Dacus ferrugineus*, *D. Zonatus*, *D. Correctus* and *D. ferrugin dorsalis* infest these fruits, the first two being very serious.

Fruit fly

By way of control, all fruits attacked by maggots should destroyed at night and some of the fallen fruits may be used traps to induce the flies to lay eggs in them which may be eas destroyed. Clensel traps as suggested by Trehan and Pin (174) may yield some good results in reducing the attack.

In Ceylon (108), the ripening mango fruits are pierced by common fruit fly (*Chaetodacus ferrugineus*) which can be co trolled by the following poisoned bait, prepared from:—

Lead arsenate	½ ounce
Jaggery (raw sugar)	12 ounces
Water	10 pints

This mixture should be placed in cigarette tins hung up on t branches. The flies are attracted to this bait and die. "Lu cages are found useful for trapping flies.

Several types of scale insects are often found to attack man leaves and fruits, and the insects can be destroyed by spr ing the trees with fish oil rosin soap in proportion of 1 : 40 parts of water.

Scale insects

The chief mango disease is the powdery mildew which been dealt with along with the hoppers, as it is associated w

Fungoid diseases

them. The other diseases such as black stem and blight are controlled by spraying with Bordeaux mixture.

Anthracnose of mango caused by the fungus *Colletotrichum loeosporioides*, is the major factor directly limiting the mango crop in Punjab and other parts of India. The disease attacks the more tender portions of the mango trees including flowers and fruits. It appears in the form of small black or dark spots on the stems, leaves and flower stalks. It spreads rapidly, flowers and flower stalks wither and the fruiting of the trees may be entirely prevented. With lighter infections on the flower clusters, some fruits may set, but later, the disease may spread to the peduncles and the fruits drop. Ripe fruits are also attacked and destroyed. To control the disease, about eight applications of Bordeaux Mixture (3: 3: 50) with a calcium caseinate spreader are needed. The first three applications are made to protect the flower clusters and the last five to preserve the newly set fruits.

The "anthracnose" which causes leaf-spots, blossom blight and fruit rot, can be controlled effectively by spraying the trees with one per cent Burgundy mixture, prepared in the field from concentrated solutions of bluestone and washing soda, diluted to correct strength properly mixed and promptly used. Weekly sprayings with Burgundy mixture have been markedly beneficial to control this disease.

In some orchards, young mango trees are found to wither from the ends of shoots which slowly darken and die downwards. In the Kathiawar area, such plants are also seen to ooze a thick gummy substance of deep brown or reddish colour, just below the dead portion particularly at the nodes and joints of old and new growths. This disease seems to be associated with heavy or over-irrigation combined with planting under shade. The trouble has not been investigated yet, and the remedy, as a first aid, appears to be to spray the affected trees with Bordeaux mixture, after the affected portion is clipped off and burnt. Frequent cultivation and clearing of shady intercrops and improved drainage may assist recovery of plants.

Loranthus is a parasitic flowering plant found growing on mango trees very commonly in this country. It is botanically named *Loranthus longiflorus*. There are several varieties of this

Loranthus

parasite, locally known as *Bandgul*, *Badani*, *Bandalka*, or *Vandha*. Its branches are droopi and the leaves are thick, succulent and light green. The plant sen its roots (haustoria) into the tissues of mango (and many other h plants) and sucks the sap taken in by those plants from the s The sap is thus prevented from going above the point of atta In course of time, the branch of mango above the point of atta by *Loranthus* dries up and if the attack is severe, the whole tr becomes weak and may succumb. The *Loranthus* itself, ho ever, thrives and grows well at the cost of the host plant. T spread and infection by this plant takes place through bir eating its fruit and depositing the seeds on the branches whe they perch. The seeds so dropped get firm hold on the branch and germinate in course of time, when the parasite grows. T only effective remedy against this is to cut all infested branch well below the place of attack and apply tar to the cut end. the attacked branches are large, the *Loranthus* can be scrap from the host stem and not allowed to grow again, by period inspection and removals. Large old mango trees are particular seen to be badly attacked by *Loranthus* and require to be pr tected against this serious parasite.

Lichens

Several cases are noticed where stems of fairly grown mango trees are badly covered with whitish superficial grow of lichens, especially in the heavier rainf tracts. The infestation is all the more seve where the orchard is neglected and the trees are weak health. The lichens perhaps do no damage to the trees directl

Teratology of mango inflorescence

Occasionally, great abnormality is seen in the inflorescen of mango. They do not set fruits, but appear like longish veg tative brooms. The axes are shortened ar thickened. The flowers are crowded, take lo in opening, have often enlarged discs and se dom set fruits. The abnormal inflorescence may persist long aft the normal one has fallen off the tree, and may finally becon vegetative. So far, no cause for this malformation has been trace It is, however, not due to either insects or fungus. The occu rence of malformation is more frequent in the Gujerat area th in other parts of the Province of Bombay.

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CHAPTER III

ORANGES AND ALLIED CITRUS FRUITS

Introduction

Oranges and allied citrus fruits are perhaps among the mos popular and extensively grown fruits of the world. Th high medicinal and nutritive value attache to them have made these fruits almos indispensable in several parts of the world. Although these fruit are sub-tropical, they are also grown in most countries in th tropics and in some favourable parts of the temperate region The commercial importance of these fruits is very great t every country which produces them. The world productio of citrus is reported to be 230,000,000 boxes per annum of which about 25 percent finds its way into export channels In the States of Florida and California, where citrus cultivatio can be said to have reached the climax of commercial frui farming, the annual crops are said to have been over 13 million dollars in value in 1935.

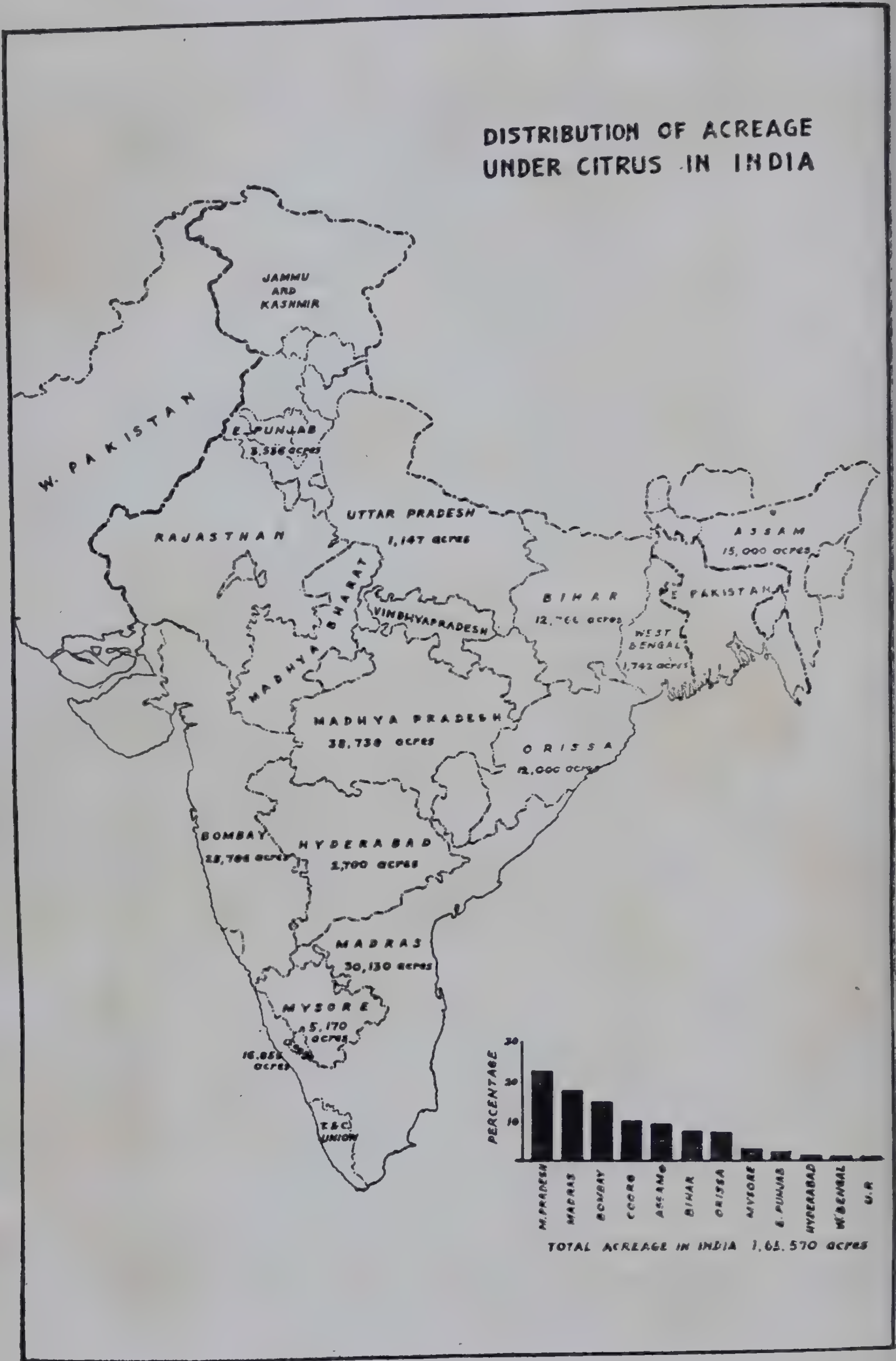
Origin and distribution

De Condolle (65) opines that citrus fruits must hav originated somewhere in the north-eastern parts of India Siam or Southern China. There is evidence to show that these fruits existed in these parts of the Asian continent in pre-historic times It appears that the varieties of citrus slowly spread to Europea countries and the American continent comparatively recently They are now grown in Italy, Spain, Palestine, California, Florida, Central and South America, South Africa, Philippines Australia, Japan and China, where they have attained an indis putable commercial magnitude. Citrus growing is carried o in these countries as a very profitable industry, both for hom consumption as well as for export of fruits and their products.

In India, the chief citrus growing provinces are Madras the C. P., Punjab, Coorg, Mysore, the southern slopes of th Cherrapunji hills of Assam, northern Orissa and the Bomba Presidency. Practically, no part of India is left where one or th other variety of citrus has not entered into local importanc

A SANTRA ORANGE GROVE IN FULL BEARING.

Facing page 138.


DISTRIBUTION OF ACREAGE UNDER CITRUS IN INDIA
JAMMU AND KASHMIR
W. PAKISTAN
E. PUNJAB
UTTAR PRADESH
1,147 acres
RAJASTHAN
MADHYA BHARAT
VINDHYAPRADESH
BIHAR
WEST BENGAL
ASSAM
15,000 acres
E. PAKISTAN
MADHYA PRADESH
38,738 acres
ORISSA
BOMBAY
HYDERABAD
MADRAS
30,130 acres
MYSORE
5,170 acres
T.&C. UNION
PERCENTAGE
30
20
10
M.PRADESH
MADRAS
BOMBAY
COORG
ASSAM
BIHAR
ORISSA
MYSORE
E. PUNJAB
HYDERABAD
W.BENGAL
U.P.
TOTAL ACREAGE IN INDIA 1,65,570 acres

Area under citrus in India is 1,65,570 acres as per table given below :—

1.	Madhya Pradesh	38,738	acres
2.	Madras	30,130	,,
3.	Bombay	25,786	,,
4.	Coorg	16,855	,,
5.	Assam	15,000	,,
6.	Bihar	12,766	,,
7.	Mysore	5,170	,,
8.	East Punjab	3,536	,,
9.	Hyderabad	2,700	,,
10.	W. Bengal	1,742	,,
11.	Uttar Pradesh	1,147	,,

Cultivation in the Bombay Presidency

There are a large number of species of citrus found growing in the Presidency of Bombay. Their cultivation is mainly restricted to particular zones which are suitable from the point of view of soil, climate and other conditions such as facilities for irrigation. The important varieties of this Presidency are the oranges, a name by which both the *Santra* and *Mosambi* are popularly designated, the lime (*kagdi limbu*), the pummelo and the citron group. These varieties are not all found occupying the same zones. They are more or less severally distributed according to suitable conditions. In fact, the orange and the lime are alone cultivated on plantation scale. The other types are mostly seen scattered as individual trees in the regular plantations of oranges and limes.

The total area under citrus cultivation in the Bombay Presidency is nearly 35,701 acres (1947-48). The two types of oranges (*Santra* and *Mosambi*) alone occupy nearly 25,646 acres of this area. Then comes the lime (*kagdi limbu*) which occupies 2,656 acres on the whole. Its cultivation is more extensively distributed than that of the oranges.

Soil

The soil of this Presidency is so varying in nature that it is practically impossible to classify it correctly under definite heads, and accordingly to describe their nature in a general way. Besides a large number of distinct types of soils, there exists a great variety of shades in what may be

called the same kind of soil. The soil varies in character almost from field to field, and many times from plot to plot. The citrus trees are grown in almost all kinds of soils of this Presidency, from a heavy black soil to an extremely shallow open soil with little fertility in it. Some of the varieties of citrus seem to adapt themselves to soil conditions better than others. In the Poona and the Ahmednagar districts, there are places with a very deep sticky soil, wherein are cultivated *Santras* and *Mosambis* with considerable success. In certain other parts of the Ahmednagar district and the Dharwar district are places with shallow stony soil, where also the citrus plants are grown. The pummelo is grown in the Konkan tract where the soil is shallow and sandy. What is generally named as the *shadu* soil (a whitish limy soil, which does not allow a free drainage of water) is common in a number of districts and is found as a subsoil from one to two feet below the surface. In certain tracts it is also found forming the surface layer and runs to a greater depth. This soil is sticky in nature and has a larger percentage of lime going up to 15 per-cent. At Kohlar in the Ahmednagar district, an attempt was made by a cultivator to grow some trees of the *Santra*, the *Mosambi* and the *Kagdi limbu* varieties in a field where this *shadu* soil was found on the surface. The plants never thrived and ultimately all of them died in less than three years from the time of planting. However, when the subsoil layers are alone of the *shadu* type, the plants grow very well for a period of four or five years. But when their feeding roots tap the lower *shadu* layer, the trouble (chiefly in the form of die-back) begins. Similar is the case in other parts of the Presidency where citrus trees are grown in shallow soils with an underlying layer of rock or stone, which the roots of citrus plants cannot penetrate. While planting in such soils, pits of the size of about $3' \times 3' \times 3'$ are taken and filled with loose soil mixed with manure. Plants in such pits grow normally for some time and then suffer from die-back when their roots come into contact with the surrounding hard layer. This condition was actually noticed on the Kumta Farm in the Kanara district where *Santra* and *Mosambi* trees suffered even at the very early age of about six years. Indian soils in general are deficient in organic contents, and wherever this deficiency is not made up by an adequate supply of bulky manures, the citrus trees suffer for want of nutrition.

In short, citrus trees are seen to thrive well in well-drained soils such as the alluvial, medium black or loamy soils such as are found on the banks of rivers or *nallas*. A hard substratum or sticky subsoil is deleterious to the health of these trees. In the Bombay Presidency, the medium black soil of Poona, Saswad and other places, the reddish, whitish or brown alluvial soils on the banks of rivers and streamlets and the loamy or *goradu* soils of Gujerat are considered well suited for growing oranges and allied fruits. In the Deccan, black or medium black soils about two or three feet in depth with murum or sand below can be selected for planting citrus trees. A high lying site in such soils may be preferred, because, however suitable the soil itself may be, there should be no chance for it to be submerged by floods in the rainy season lest the trees suffer. A high lying site has also the advantage of natural drainage.

Soils characterised by a high percentage of sand and a negligible quantity of clay are almost always regarded as unsuited for citrus cultivation in California. Water percolates easily in coarse soils carrying with it the finer particles, and leaching a large part of the more easily soluble fertilisers. A survey of Valencia orange groves in the United States of America revealed that orchards located in good medium loamy soils give best production and income (335). In Palestine the best soil for citrus cultivation is considered to be the one containing a medium amount of loam (193).

The presence of a high water table renders the site unsuitable for citrus trees. Although the optimum depth of the water will vary in different soils and locations, it is safe to state that any soil which has a water table nearer than six feet from the ground level is unsuited for citrus cultivation. Not only the permanent water table, but it is the fluctuating table also that causes considerable damage to the roots.

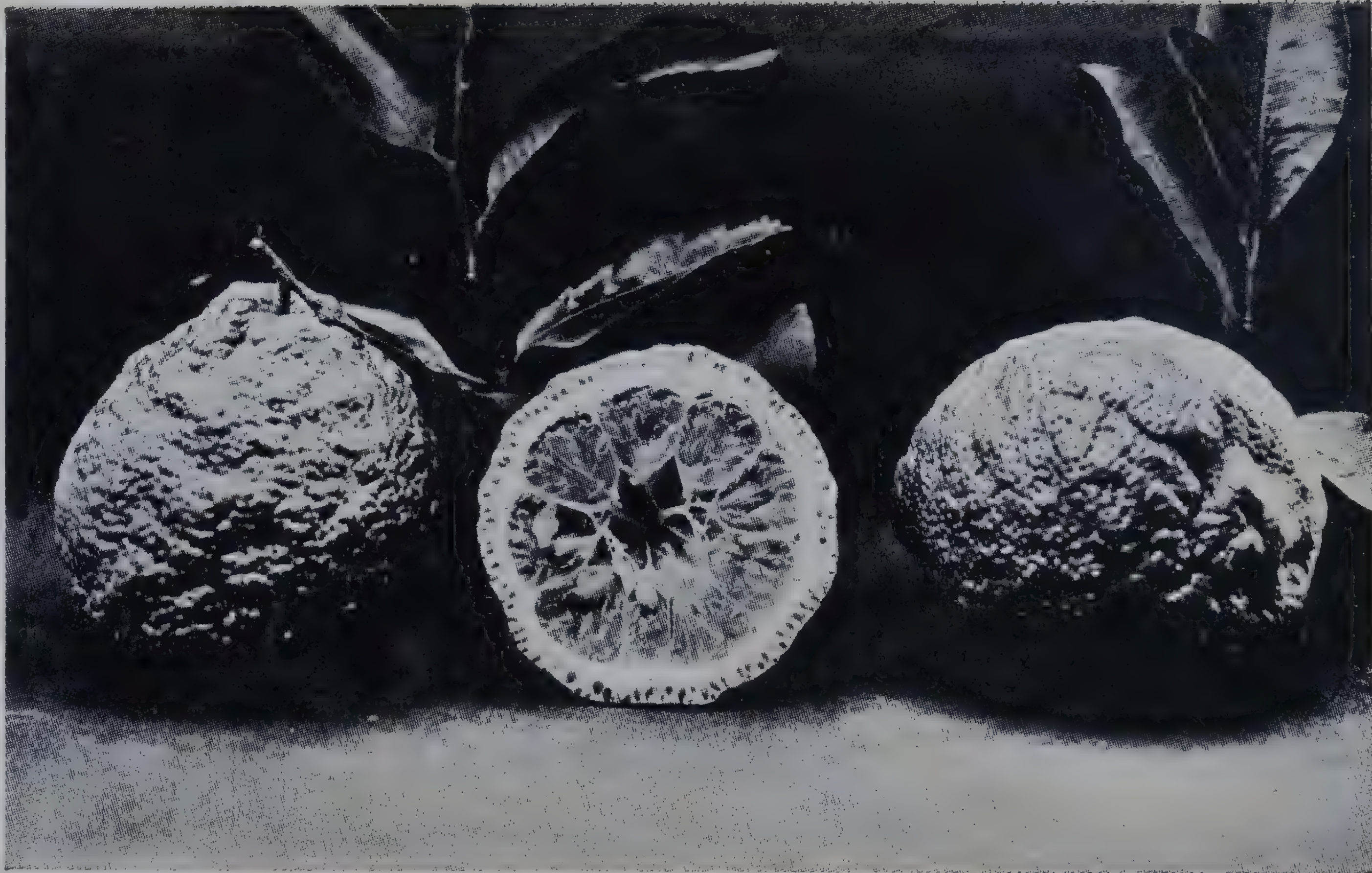
Citrus trees are quite sensitive to alkali and especially to sodium chloride (140). Irrigation waters containing sodium chloride should, therfore, be strictly avoided. Flood or some form of basin irrigation may be adopted where saline water is the only irrigation supply in order to effectively leach the salts down into the subsoil. Reed and Haas (207) have shown that while the presence of calcium salts was necessary for the successful growth of young orange trees, and serious injury occurs to trees

in the absence of these salts in the soil the absence of potassium salts did not produce any marked ill-effects. A good soil was associated with relatively high calcium especially in the root zone and relatively low sodium content, and the poorest soil with relatively low calcium and very high sodium content. The sweet orange is adapted to deep light soils of basaltic nature and gives much greater longevity when used as a rootstock. For grapefruit and lemons, the common lemon is recommended as a rootstock in such soils (342).

Rainfall

Citrus trees in general are not seen to thrive in heavy rainfall tracts like the Konkan. *Santras* and *Mosambis* do grow well for some years in a rainy and moist tract, but they do not fruit well. A drier climate with an annual rainfall up to thirty inches as is obtained in most parts of the Deccan is better suited to *Santras* and *Mosambis*. In well-drained lands or on hill slopes, like those in Coorg, the *Santra* oranges tolerate a high rainfall, exceeding even 100 inches per annum. Within reasonable limits, it would seem that it is not so much the actual quantity of rain that falls, but the distribution of that quantity and the facilities that prevail for drainage which matter. The *Santra* requires in Bombay Presidency even a drier climate than the *Mosambi* does. This is seen as one proceeds towards the east of the Deccan plateau where *Santra* plantations thrive better than on the borders of the Ghats towards the west where the rainfall is more and the climate is moister. The *Mosambi* plantations also yield sweeter fruits in the drier tracts than in the more rainy places. In the Khandesh districts *Santra* oranges grow to excellence as the tract approaches the Central Provinces and the climate is nearer the one which prevails in that province, which produces the famous Nagpur oranges. Pummelo can stand a heavy annual rainfall and thrives in the Konkan tract. In fact, pummelo trees do not bear good fruits in the drier Deccan climate. The *kagdi limbu* trees also thrive well in the North Kanara district, where the annual rainfall goes above 120 inches, but they do not seem to dislike the dry climate, provided there is enough irrigation. Extensive *Kagdi limbu* plantations are seen thriving in the Poona, Nasik and Khandesh districts, where the rainfall does not exceed thirty inches annually.

It has been stated that the original home of some citrus varie-



JAMBURI FRUITS.

This is the chief root-stock variety in Western India.

es is the foot of the great Himalayan Mountains, from which is evident that they can naturally grow up to a considerable height from the sea level. The average altitude of the Deccan plateau, at least of that part of it which falls in the Bombay Presidency, is not more than about 2,000 feet. These places are, therefore, very favourable for citrus trees. In this Presidency no damage is caused to them by low temperature, as frost generally does not form a feature of its eastern parts. The higher temperature of the eastern parts of the *Desh* (Deccan) tract is considered very helpful in producing quality fruits.

Altitude and temperature

In Ceylon, lemons are grown in semi-dry areas at 3,000 to ,500 feet. Some South African lemons showed good progress n that country.

As stated above, the Presidency of Bombay grows only the *Santra*, the *Mosambi* (the Mozambique or sweet orange) and the lime on plantation scales. Besides these chief commercial varieties, there are in this Presidency, about twenty other varieties found scattered in different places as individual trees. The oranges of Bombay fall into two distinct groups, namely, the close-skinned or tight-jacket oranges, and the loose-skinned or loose-jacket oranges. Both were considered till lately by some people to belong to a single species. Their common botanical name was accepted to be *Citrus aurantium*. Bonavia (39) differentiated these two groups into *Citrus aurantium sinense*, Gallesio—close-skinned oranges, and *Citrus aurantium sinense*, Rumpjius—loose-skinned oranges. But the two groups differ widely in many points, and they rightly fall into two separate species. According to the scheme of Swingle, the close-skinned *Mosambi* group of oranges goes under *Citrus sinensis* Osbeck, and the loose-skinned *Santra* group or mandarin group goes under *Citrus nobilis lour*, which Swingle has now altered to *Citrus reticulata*, Blanco. There are further what may be called horticultural varieties in these species. *Citrus sinensis* Osbeck, includes the *Mosambi* orange, the Navel orange, Valencia and a large number of other varieties. The *Mosambi* is a distinct variety, and is at present of great economic importance in this Presidency.

Varieties and their classification: Oranges

The mandarin orange (*C. reticulata*) represents a group that

has no less than four different varieties grown in this Presidenc
They are the *Santra*, the *Kavla*, the *Ladoo* and the *Reshmi Narang*
The *Santra* is perhaps the best of the loose-skinned types of orange
Tanaka (284) appreciates it as unequalled in quality and name
it as *Citrus poonensis*, Hort. ex. Tanaka. Hodgson (122) think
that the *Santra* is identical to the famous *Ponkan* of Souther
China, which opinion is also shared by Milsum (176) who, there
fore, designated it as *Citrus chrysocarpa* Lush. The other types ar
inferior to the *Santra* orange. They are also different from on
another and may be considered as separate horticultural varietie

Citron and lemon types

The citron, the lemons and the limes were all considere as only varieties of *Citrus medica* according to Linnaeus. Swingl isolated them into three separate species, *Citru medica* Linn, (citron), *C. limonia* Osbec (Lemon) but most recently—*C. limon*, Lin Osbeck, and *C. aurantifolia*, Swingle (limes). The lemons o Bombay present at least two and possibly three horticultura varieties of *Citrus limon*. They are *Jamburi*, *Id limbu* and perhap also *Sakhar limbu*. The first two are sour (or rough) lemons, whil the last named is sweet. The *Sakhar limbu* is also widely know as sweet lime and designated by a number of authorities a *Citrus aurantifolia*. Hodgson (122) considers that this frui is of Indian origin and resembles the Persian lime from which i differs in its large size and different form. On these considera-tions, he believes that it comprises a good botanical specie Tanaka (296) has also formed the same opinion and has desig-nated it as *Citrus limettiodies*, Tanaka. It seems safe to trea this as a hybrid, till taxonomic opinion entitles a definite opinion

Limes

The limes fall into a distinct species, and are named *Citru aurantifolia*, Swingle. These include such varieties of Bomba as the *kagdi limbu*, and also the *godhadi limbu* and the *pat limbu* whose exact specific status i yet to be determined. The *godhadi limbu* has thicker skin tha the *kagdi* (papery) *limbu*. The *pat limbu* is longish in shape, whil the others are globose.

Much confusion in the classification of Citrus appears to b due to the lack of a standard horticultural system of classificatio as distinct from the systematist's idea of classification. Th maze of species, varieties, strains and mixtures of cultivate citrus is ever on the increase, and unless a united effort is mad

r the workers on citrus to adopt a universal system based upon a udy of the genetics, bio-chemistry, physiology and karyology of e citrus race, the existing confusion is bound to continue. ozhin (144) states that "A species should be, as is Linnean, netically an aggregate unit, and the result of a whole system of ementary forms, which, continually crossing with one another ep within the limits of definite specific characters." If this is cepted, Tanaka's (273) attempt to give specific ranks to seedless arieties, which cannot even reproduce themselves true to type ithout man's interference is unsound.

The important citrus fruits grown commercially in the rest of dia and Pakistan are the following:—

ther citrus uits in India

The Punjab, North West India, Sind and Western U. P.:—

Malta and blood red oranges, (*Citrus sinensis* Osbeck); *Santra* (*C. nobilis*, Lour or *C. chrysocarpa* Lush or *C. reticulata*, Blanco); *Mitha* or sweet lime (*C. limetioides*, Tanaka or a hybrid), and a number of strains originated from chance seedlings not yet identified.

Lower foot of Himalayas:—Limes (*C. aurantifolia*) and a number of strains of lemons (*C. limonia* or *C. limon*).

Assam:—Strains of *C. nobilis* or *C. reticulata*.

Central Provinces, Western part of Orissa and Agency tract:—*Santra* mainly. Two strains, one with smooth skinned round fruit, and another with a slightly warty skinned fruit, drawn out towards the stylar end.

South India:—The mandarin is of considerable importance in Coorg agency tracts, lower Palni Hills, Yercaud and the Orange valley of the Nilgiris. Two varieties of sweet oranges (*C. sinensis*, Osbeck), namely, Batavian oranges and *Sathgudi* (Syn. *Satkudi* or Chinee) are grown in the northern or north-eastern parts of the Madras Presidency. *Mosambi* oranges are also grown on a small scale in the Kurnool district. Acid limes (*C. aurantifolia*) are grown on a very large scale in a

large number of districts particularly Northern Circars, Ceded districts and parts Madura and Tinnevelly. Pummelos a prominent on small orchard scale in t West Coast and Northern Circars. A varie of sour oranges known as *Vadlapudi* or Gu tur sour oranges is of considerable comm cial importance in Northern Circars, par cularly in Guntur and Kistna. The Madr Presidency is also rich in a number of citr varieties ostensibly having their origin chance seedlings, one of which has be recently identified as *Citrus maderaspatan* Tanaka, and is receiving attention now as possible rootstock variety of value for cul vated forms of oranges and limes.

In India, citrus has produced a host of new types, as t various cultivated species have access to other conjugally co patible species. Chance seedlings have appeared and ha produced a notable increase in varieties of all kinds of citr species. In the regions of South India, where seedling plant tions are still the rule, several citrus have originally appeared chance seedlings just as the Satsuma orange had done in Japa Hodgson (122) has stated that the very large number of peculi and some very distinctive citrus fruits which occur in Ind form one of the interesting features of Indian citriculture. T multiplicity of these forms renders the task of classifying the botanically or horticulturally great and difficult.

The chief commercial varieties of citrus, namely, t oranges, are propagated in Bombay Presidency by buddi

Propagation

them on rough lemon (*jamburi* as it locally called) rootstock. Other variet like *Kagdi limbu*, pummelo and citron are grown as seedlin and no budding is yet being done commercially in their ca The method of budding adopted is the shield method, wi no wood attached to the budshield, and it is the pride several gardeners that the success they attain with this meth is cent percent. *Kagdi limbu* is lately being budded *jamburi* on a small scale and so are the new introductio namely, the Navel Orange and the grapefruit.

Jamburi, or the rough lemon, is acknowledged as the best com-
ercial rootstock variety for raising citrus types in Bombay Presi-
dency. It is a very inferior and hardy variety of citrus and belongs to the lemon group.

.ootstock

: has come into prominence in commerce in the Bombay Presi-
ency and in fact all over India, only as a rootstock variety, hich combines in itself all the desirable qualities of a good otstock. It is never cultivated independently on a plantation ale. One or two or a few trees of this variety are generally en in plantations of *Santra* or *Mosambi*. Their fruits are not sed except for pickling purposes. Their seeds are the only roducts of economic significance at present.

Jamburi as a rootstock is referred to by Paranjapye (193) the following words: "The essential conditions required in a ock are that it must remain in sap flowing condition for a considerable time to facilitate the budding operation at any suitable time; that it must grow fast; that the bark hen being loosened from the wood below must separate readily; at it should not tear irregularly; and that it must feel very atery to the finger inside. Such a stock is to be found in *mburi*, which may be safely used for budding on." The posi-
on of *jamburi* as a rootstock in comparison with other kinds f rootstocks tried here is made clear by the same author 193) in the following words: "The bark of the *Mahalung* Citron) stock is somewhat brittle and less mucilaginous and the p flowing condition lasts only for a short time. The *Reshmi* ange is not at all suited as a stock, for the bark closely adheres the wood below and it is not moist enough inside. This and the agpur orange stocks when cut off above, the wood often turns ack near the cut end causing ultimate decay. With e pummelo (shaddock) as the stock, the great difficulty that it does not stand well the trimming of its tap root and ence it is not well suited as stock plant, which must stand re-
eated transplantings. The *Mosambi* stock is very sensitive to old, as in case of low temperatures the part of the bark of the em that remains under water decays in a very short time. he *jamburi* stock is free from all these faults."

Aerits of *jamburi* s a rootstock

An experiment laid down in 1932 to find out if certain root-
ocks could resist the die-back disease prevalent in Bombay

Province, showed the growth of *Mosambi* on *jamburi* to be bet
than the remaining rootstocks (217).

Jamburi is a popular rootstock in all parts of India and h
also been found experimentally to be the best for Malta orang
in North West India by Brown (46).

The most important rootstock varieties in use in other parts
India and the world are listed below. They are discussed
detail by Hatton (114).

Other rootstocks

1. Sour or Seville orange (*C. aurantium* Linn):—Accordi
to McAlpin (168) among the four chief rootstocks used in Vi
torian citriculture, *viz.*, citronella or roug
lemon, sweet orange, sour orange and tr
foliate orange (*Poncirus trifoliata*), a disease affected 30% of th
trees on sour orange rootstock, and appears to be similar to th
"quick decline disease", of the U. S. A. or the "tristeza" disea
of South America. Further plantings of citrus varieties on sou
orange have been discontinued until a remedy for this disease
found. Similar reports have been published from other area
too, so that the sour orange is now in disfavour almost all ove
the globe.

Sour orange was once considered to be the most suitabl
stock for Southern Nigeria (211). Hume (129) stated tha
a large part of the world's commercial output of citrus wa
grown on this rootstock. It is said to possess an abundant an
deep root system and is considered to be the best on heavy an
wet soils. It is also said to be immune to foot-rot and all th
gum diseases, but very susceptible to citrus scale and to quic
decline disease. Trees on this rootstock are reported to be no
very free bearing in the early stages, but the fruit quality is sai
to be better than on rough lemon.

2. Sweet orange (*C. sinensis* Osbeck):—This is very susce
tible to *Mal de Goma* foot-root, and is unsafe to use except o
light and dry soils. It has a shallow root system but produc
shapely trees (189). Recently in California sweet orange roo
stock is reported to be gaining popularity (232).

3. Trifoliate orange: (*Poncirus trifoliata*, Raf):—This
used as a rootstock in China and Japan. It does not do we
under tropical conditions. Its value lies in its being the hardie
of all rootstocks and is therefore used in frosty localities. I
has a dwarfing effect on the scion.

According to Benton (21), *P. trifoliata* is to be regarded as a .luable rootstock under a variety of conditions in New South ales. Apart from its immunity to *Phytophthora* root-rot, it s ability to thrive in soils too moist for other rootstocks, has neficial influence on flavour and fruit quality in general, duces early bearing and possesses a tendency to increase oduction.

4. SHADDOCK (*Citrus maxima* Merril or *C. grandis* Osbeck):— Egypt it is supposed to be valuable as a rootstock on dry land. is immune to foot root. In the Philippines it has been found at plants budded on Shaddock are liable to be badly affected mottle leaf (152).

5. GRAPEFRUIT (*C. paradisi* Macf):—The root systems of ummelo and grapefruit are reported to be more fibrous than at of either sour or sweet orange, but these have a small and ooked tap root. The lateral spread of roots is enormous. is somewhat susceptible to foot-rot, and certain kinds of ımmosis. On the whole, accounts vary about its success in her parts of the world.

6. ACID LIME (*C. aurantifolia*, Swingle):—The plants of this ecies are rather difficult to work upon. According to Brown 7), it is a suitable rootstock for scions of its own variety. It not used on any large scale for other scion varieties. Very cently it has shown encouraging performance when used as a otstock for sweet orange and lime at Kodur.

7. SWEET LIME (*C. aurantifolia*, var Swingle, syn. *C. limmet-ides*, Tanaka or a hybrid):—In North-West India, this is used irly extensively as a rootstock for Malta oranges and *Santra*. the rootstock trials in North-West India (47) it was found at the sweet lime is not a suitable rootstock for Malta oranges t perhaps the best for *Santra*. It is easily raised from cuttings, d is being used as such in the rootstock trials in some research tions in India. With rough lemon, this forms one of the two st important rootstocks for *Santras* in the Central Provinces 36).

8. CITRON (*C. Medica. L.*):—A variety known as *Mokri*, largely used in some nurseries in the United Provinces and the njab. It is also in use on a small scale in Egypt. It is very sy to work upon and produces very quick growth in the initial ges. But because of its reported susceptibility to diseases and

its short orchard life, this rootstock is held very much in d
count.

9. Mandarin orange (*C. nobilis*, var. *deliciosa*, Swingle
C. reticulata, Blanco):—This is used in China and a variety
this (Cleopatra) is also found suitable in well drained san
soils of Florida. It is said to be immune to scale and resista
to gummosis. Tangerine is used as a rootstock for its own sci
in South Africa.

Some experimental work is being done on the indigen
citrus rootstocks of Assam at the Government Citrus Fr
Research Station, Bernihat. The relative merits of *Rabab Ten*
(*C. grandis*), *Soh Myndong* (*C. jamburi*), *Pani Jamir* (*C. limo*
Karun Jamir (*C. curantium*), *Sat Kora* (*C. macroptera*) sto
are under investigation. The scion used is Khasi orange (
reticulata). *Soh Myndong* is important for imparting maximu
growth to the scion. *Rabab Tanga* has recorded the maximu
stock girth. *Pani Jamir* rootstock, which is somewhat sweet a
insipid has produced very sour fruit with Khasi orange scion.

There are a number of other varieties in limited use
various countries. *Citrus sunki*, Hort. is of some importance as
rootstock in Japan. In the Madras Presidency, a number
varieties that have originated as chance seedlings and appear
have potentialities as rootstocks have been recently prop
gated and are being tested for their suitability to sweet orange a
acid lime scion varieties. In the Punjab and Central Pr
vinces also, rootstocks of different varieties are being examin
for their value to Malta orange and *Santra* respectively. T
work of discovering the right type of rootstock for the cultivat
citrus varieties grown under diverse climatic and soil conditio
in India is highly important, and in this work the possibilities
indigenous citrus varieties require to be tested along with the we
known varieties in use in other countries.

The citrus rootstock experiment carried out at Montgome
(Punjab) showed that *Kharna Khatta* was useful for all citr
varieties there except in the case of Blood Malta, for whi
rough lemon was found to be the best stock. *Jullundri Khatti* w
a mediocre rootstock for the local Malta and was not associat
with vigorous growing trees with heaviest yields of excelle
quality fruit (217). What these rootstock varieties are exact
is yet to be determined by proper taxonomic studies.

Halma (106) reports that Eureka lemons on their own roots, er 16 years proved to be less vigorous, less hardy and less oductive than vegetative progeny of the same parents budded grapefruit and sweet orange rootstocks.

Hodgson and Cameron (123) report that in citrus trees it s been established that the scion determines the rate of owth and ultimate size of the tree when its vigour is less an that of the rootstock.

There is evidence to show that certain strains of a species parently produced better results than other strains of the me species. If this is true, it represents a more extended oblem of rootstock influence, and, therefore, has to be taken to account in our future rootstock trials.

In a rootstock trial in Bombay, it was found that seedlings of fferent strains of *jamburi* varied considerably in their general rformance and vigour of growth under strictly uniform condi-ons (56).

In Queensland, seedlings of sweet orange and rough lemon ere popular as rootstocks, while sour orange is less common ssibly because of its slow growth (202).

In California, the tendency in 1936 was towards the suppression the sour by the sweet oranges as the principal rootstock variety r the oranges. Rough lemon was rarely used (165).

Different soils react upon the rootstock to produce in some ses very vigorous trees and in others short-lived and weak dividuals. The grower has also to understand that the prob-m of orchard culture does not merely rest in terms of the uality of water or manure applied, but also in the optimum use ade of the moisture and soil nutrients by the roots. The portance of root system lies not only in its anchoring the tree, t also in its power of absorption of moisture and soil nutrients. deep and extensive root system is helpful in giving the desired echanical support, and in retarding the desiccating effect in e soil. This fact becomes progressively important as the oisture content and fertility of the soil diminish. An exten-ve root system is inhibited under constant wet soil conditions, t is encouraged under conditions of good aeration and oderate water contents. The root system of some varieties is uch more extensive than that of others. Soil texture and ructure also affect the depth and spread of roots to a con-

siderable extent. It is, therefore, most necessary to selec rootstock variety that will produce the best of root systems o given site and can promote the best of growth and produc within the available soil and water facilities.

Kharna Khatta irrespective of scion varieties is associa with most vigorous trees. *Jatti Khatti* gives vigour to its scio a lesser extent. Mitha or sweet lime (*C. aurantifolia*) dwarfing stock (150).

The foundation of the citrus nursery industry in the Bom Presidency is built on *jamburi* seedlings, which form the st for all the superior varieties of citrus. *Jamburi* seedlings raised from fruits which are ripe on the tree. The *Sakhar li* rootstock is also raised in some places for budding purpose.

Types of *jamburi*

There are a large number of types of citrus which go un the name of *jamburi* or *jambiri* or *jamberi* in different localitie India. These types differ considerably shape, size and appearance of the fruit. W is generally known as *jamburi* in the Bombay Presidency d not also seem to be a uniform type all over the tra The collection of citrus varieties at the Modibag, College Agriculture, Poona, consisted of several types which were named as types of *jamburi*. Each tree bore fruits that were some way or other different from those of its neighbours. T characters of fruit alone give, therefore, no indication to type of *jamburi*. The type of *jamburi* commonly used for st in this Presidency has deep yellow colour, has a mammill shape and the fruit is nearly round with a diameter of ab three inches. The rind is wrinkled and somewhat loose. T pulp is exceedingly acid.

Fruiting seasons of *jamburi*

Jamburi trees bear almost all the year round in pen sular India. The three important seasons, namely, the Dece ber-January flowering, the June-July flow ing and the October flowering all prod some blossoms at least on the trees. *Jamb* fruits are therefore, available almost at any time of the ye although the chief season is July-August. In north and sou India, *jamburi* fruits are chiefly available from October January.

For the purpose of extraction of seeds, sound, healthy a tree-ripe fruits should be selected. Such fruits are allowed

traction of seeds

rot, or are cut fresh and their seeds extracted. The seeds that float on water are useless for sing seedlings, and they should be rejected. Only the heavier ds, which sink in water should be collected and used.

Seeds are then spread on ordinary blotting paper or on · floor under shade for drying for a day or two. Then

ring of seeds

they can be stored in a tin or glass jar till required for sowing. Mixing with ordinary wood ı before storing is desirable. *Jamburi* seeds have to be proted from rats and insects, while drying as well as while in store. e *jamburi* fruits contain about 25 seeds each. These seeds ı well be graded into heavy and light seeds, and the former · experimentally proved to give more vigorous seedlings ich become ready to receive the buds much earlier than the dlings raised from lighter seeds.

iyembryony in ds

Seeds of *jamburi* are polyembryonic as those of most ıer citrus. From one to eight embryos (or perhaps more) are seen packed together in a single seed. Each embryo has generally two cotyledons which are very irregular in shape except en the seed contains only one embryo. In polyembryonic ds, one of the cotyledons is the largest of all, while one or ɔ more may approach it in size. The rest are very thin d small, and may be reduced to almost translucent scales, ecially when they are placed in the interior of the d. When the seeds are sown, some of the more vigorous bryos are seen to develop into seedlings. It is for this reason t more than one seedling are seen to spring up at a place ere only one seed is sown. The number of seedlings ing from a single seed may be four or more in number. More r half the number of seeds, give rise to two or more seedlings. e vigour of all seedlings arising from a single seed is not the ıe. In fact, it varies remarkably. One of the seedlings is most vigorous of all. Others follow in regular gradation. e difference between the best and the second best seedlings is siderable, going as high as about 50 percent. Seedlings t come next in order are really too weak to be considered. viewing the literature (114) on polyembryony it is stated t the presence of more than one embryo within the seed may ascribed to a stimulus received by the cells of the nucellus

both above and below the embryo-sac, even though separat from it by several cells. As neither spore nor egg-cell is involv in this reproduction process "the formation of these additio embryos may in effect be regarded as a case of adventiti budding, analogous in its results to true vegetative reproductio Only one seedling is a true cross, while others which may numb as many as ten, will in no way differ from the mother pla Toxopeus (305) shows that the generative offsprings, as disti from the vegetative seedlings, of Japanese citron and rou lemon, amount to only a small percent in the latter and may fifty to sixty percent in the former, and show very poor grow and are, therefore, easily distinguishable. If the weakest see lings are removed, it will result in the retention of the seedlin that would show less genetic variation. Webber (323, 331) h confirmed the value of this type of selection in citrus nurse practices, but proceeds to point out the necessity for selection large sized seedlings in the nursery even among the apogamic nucellar seedlings.

In the nursery it will be, therefore, profitable to remove the very early stages all the multiple seedlings, leaving only t best and the second best. This will do away with a good de of congestion for the seedlings, and will save the remainder fro unnecessary competition in regard to space and plant foo It will also eliminate very considerably variations in the seedlin which are further on to serve as rootstock plants, by getting r of all the generative seedlings which are the weaker ones noted above.

A number of *jamburi* seeds are found to have their seed coa split even while they are inside the fruit. The split seeds do n seem to differ from sound ones in their gener characters. They look healthy and normal all other respects. They are, moreover, mos of the larger seeds and amount to about twelve percent the total number of seeds in the fruits. The splitting or openi of the seed coat is one of the various changes a germinati seed undergoes. It seems that these split seeds have alrea started on their course of germination. This shows that t seeds have a natural tendency to prepare themselves for g mination immediately after their development is complete.

Seeds with split coats

ft long enough, the split seeds germinate inside the fruit itself s it often happens in overripe fruits.

Heavy seeds of *jamburi* are graded out and sown in raised seed eds. Such seed beds have the advantage of permitting better

owing of seeds

drainage of the soil. The land is first of all dug well to a depth of about six inches. All he clods are broken and manure is added to the land at the rate f about twenty pounds per running yard of the bed. Seed eds are ordinarily three feet broad and ten to twelve feet long. f the soil is clayey, a basket (30 pounds) of fine sand may be dded to every running yard of the bed. The whole lot is then vell mixed and worked into the ground soil and levelled. This sually raises the bed area about six inches above the general round level. In the raised bed, seeds are sown in straight lines cross the bed at a distance of about six inches apart, and covered vith about an inch of the soil and pressed well. Copious watering is done immediately after sowing. Water is then given laily once to sufficiently wet the bed.

Reichart and Perlberger (216) working on the diseases of itrus in the nursery beds, recommend that the best nursery soils or citrus beds should have a sufficient supply of plant food and a igh water percolating capacity. A soil containing four parts of andy clay with one part of old crumble manure of more than wo years old is the best. If fresh manure or organic matter as lry leaves or straw is added, it favours the spread of disease. The soil surface of the seed bed should be at least ten centimeters igher than the surface outside, and the beds should be covered with at least two centimeters layer of sand or gravel, and the eeds should be sown four to five centimeters apart. Excessive umidity is caused by closer sowing. Watering should be frugal out frequent, and only the upper layer should be kept moist till germination occurs. Three to four weeks after sowing, the upper ayer should be kept as dry as possible and the lower layer moist. Collar of the plant should in no circumstances be kept moist.

Observations made on germination of *jamburi* seeds have hown that they are very active in germinating when quite fresh.

Germination of seeds

Their activity declines rapidly after extraction from the fruits. It comes down to a certain degree in about nine days and this degree of activity is maintained for a long time. The length of germination period

varies vastly. It may extend from 22 days to about 80 da In general, this period appears to be comparatively long in t case of fresh seeds, that is, when the seeds have been in store not more than about a fortnight. Seeds sown after keeping long periods in store have a much shorter period of germir tion. *Jamburi* seeds can be preserved without materially losi their viability for about four months. If sowing is delayed about a week or more, the seeds start germinating a little la than when they are sown fresh. This delay which may about a fortnight need not lead nurserymen to think that t seeds have lost their viability and will not germinate. Hur (129) also records that citrus seeds do keep for "several month without losing their viability.

Nursery beds

Germination is seen first about three weeks after sowing done. Until then, no disturbance should be caused to the su face of the bed or else some germinatir seeds may be damaged. Germination ma last for over two months and until then care should b exercised in removing the weeds from the beds. When seedling have grown for about a month, all weeds may be remove and the interspace between the row of sowing may be lightl stirred with a weeding hook (*khurpi*). When the seedling are about two months old, it is time to thin out some of th weaker ones, and to clip off the multiple seedlings arising fron the same point so as to relieve congestion, and to afford spac for the proper growth of the remaining seedlings. At the sam time, the seedlings should be daily examined for caterpillar of lemon butterfly which look like dirty droppings of birds in th initial stage and which eat the young leaves and shoots of the seed lings. These tiny insects should be hand-picked and killed. I this care is not taken, the seedlings will all be seriously damaged When the seedlings grow up, this trouble is not so seriously felt The caterpillars are more common in the rainy season. Whe the seedlings are about three to four months old in the seed-bed they are removed carefully and transplanted in flat beds or o the side of ridges and furrows specially prepared for them. Th ridges are about two feet apart and seedlings are transplante on one side of the ridge about a foot or less apart. In flat beds transplanting is done in double rows about a foot apart, an separated by two feet distance from the adjoining double rows

RAISED SEED BEDS WITH CITRUS SEEDLINGS MEANT FOR STOCKS.

Facing page 156.

CITRUS NURSERY BEDS

ach bed has four rows of seedlings in all and the seedlings are ansplanted singly. These beds are called nursery beds and ose planting in them is favoured, as by close planting seedlings enerally grow erect and form few lateral shoots. A straight and ect stem is essential for budding upon.

Nursery beds are watered immediately after transplanting, nd again after four days, and then regularly at intervals of eight to ten days. Weeding and stirring the soil are of importance as the vigorous growth of the edling depends on these operations, as much as upon occa- onal manuring, consisting of light doses of sulphate of ammonia r cattle urine. Manures are usually given just before or after rigation turns. The soil is also stirred at least once in a month.

Care of nursery beds

In order to develop good rootstocks, the side shoots produced y the seedlings are nipped off every now and then; the earlier ney are so treated the better, as they leave no mark on the main tem. If they are clipped when branches have formed wood, ne main stem becomes knotty, and unsuited for budding. With nis treatment, seedlings become ready to receive bud in about year from transplanting in nursery beds. If large seeds are elected for sowing and then if vigorous seedlings alone are orted out for transplanting, they may become ready for budding n about a year from sowing the seeds.

Roguing out the variants or undersized plants from citrus eedlings in the nursery beds is shown by Webber (331) to be very important for obtaining only vigorous and uniformly growing seedling rootstocks of pogamic or nucellar origin. Observations collected at Poona n the graded seedlings have shown that:—

Grading of seedlings

1. The first class seedlings show better growth than the the second class seedlings even when they are young. They make a more rapid growth when they once get a start, and establish remarkably their superiority over second class seedlings.
2. The poorer second class seedlings develop side branches at a much earlier stage than the more vigorous first class seedlings.
3. At the age of four months, the first and the second class seedlings attained a girth of 1·44 cm. and 1·29 cm. and at eleven months these girths were

2·90 cm. and 2·0 cm. respectively. At this a the first class seedlings were fit to receive the b while the second class ones were not.

It is convenient to bud the rootstocks at a height of abo six to eight inches (15 to 20 cm.) from the ground. The roo stock plants should, therefore, be straight and without branch upto a height of about 25 cm. at least to facilitate the buddi operation. Branching below this height greatly diminishes t thickness and vigour of the main shoot of the rootstock plan Nurserymen accomplish these by two methods:—

1. Small seedlings are transplanted in beds as close one another as possible, only leaving enough spac just to do the budding operation convenientl Close planting in this way naturally discourag the branching on the sides of the seedlings.
2. As an additional precaution, they remove by han all the side branches that might arise on the low 25 cm. of the rootstock by nipping them in the bu A clear rootstock stem is thus obtained.

It is evident from this that first class seedlings have a natur tendency to grow without branching in their earlier stage, an provide the best rootstock from the nurserymen's point of view They may not require any special attention to secure a clea stem of about 25 cm. in height. Another point the first cla seedlings have in their favour is that they grow very vigorousl when they once get a start. This is important from the poin of view of the planter. Rootstock plants must also be health strong and vigorously growing. Buds inserted on vigorou rootstocks grow very fast and give the best plants. As the roo stock forms the foundation of the future tree, it is essential th only the best rootstock plants are always selected for use.

For the actual budding operation, it is necessary that th rootstock plants should be in sap flowing condition in order th the bark may split easily and that the buds may "take" quickl But it is also necessary that the rootstocks attain a minimum sta of maturity, when they can be budded upon. This minimu stage of maturity is reached by the first class seedling much earli than by the second class seedlings. High budding has bee recommended by some as a preventive measure against the atta

of gummosis. This disease is generally seen to start from the bud-point and spread upwards. It is encouraged by wet conditions of soil. If the stem and particularly the bud-joint is kept free from contact with the soil or irrigation water, it is suggested that the incidence of attack will be minimised. The bud-joint can be kept away from the soil or water by budding the rootstock plants sufficiently high. Budding at a height of at least 18 inches is recommended. If this has to be achieved, it is necessary that only very vigorous seedlings should be selected as rootstocks, because in some cases weaker ones do not take buds sufficiently high. First class seedlings are, therefore, to be favoured from this point of view also.

Budding

When stock seedlings are about a year old after transplanting from the seedbed, they are budded upon with buds of *Santra*, *Mosambi* or other superior types of citrus. The method of budding commonly adopted in the Bombay Presidency is the shield method. It consists of giving a 'T' or an inverted 'T' cut in the bark of the rootstock plant in a suitable place about eight to nine inches from the ground or where the bud is to be inserted. The bud from the scion stick is carefully removed by cutting it off the budstick along with a slice of bark. This is then inserted carefully inside the bark of the rootstock with the growing point of the bud upwards, and tied with a strip of fine banana fibre. While thus bandaging, the growing point is kept open in order to allow it to sprout and grow. The bud should be preferably inserted on the northern side of the rootstock to prevent direct rays of the sun falling on it and drying it up after insertion. As an additional precaution a leaf of the rootstock may be removed and tied over the bandaged portion to shade the bud for some time after budding. When the cut on the rootstock is straight, it is usually necessary to bend the rootstock stem slightly towards the operator, so as to make the bark open out naturally and permit the insertion of the bud. In this case the bark of the rootstock holds the inserted bud tightly when it is released back to its natural erect position, and contact of the uniting surfaces is facilitated.

Contrary to the prevailing practice in some parts of India, it is found that in many parts of the world the practice is to use bud-shield with a piece of wood attached to it. This practice has also been found at Kodur (Madras) to produce a greater success

in budding and to promote a better growth of bud sprouts. The budders are also able to turn out more work per day. This system, however, has not gained popularity as yet in commercial nurseries in some parts of this country. In South India, paraffin cloth is used in preference to banana fibre as a tying material around the budded region.

Selection of buds

Just as it is essential that the rootstock should be in sap flowing condition for success, it is also necessary that the buds in proper condition are selected for the purpose. Young shoots of citrus are generally tender and angular. Growths which are one or two seasons old are more mature and rounded. Small discontinuous streaks of greyish colour also appear on them. Such branches should be selected as sources of buds for propagation. The trees from which bud-sticks or bud-woods are taken should be in a growing state, so that the buds are in a sap flowing condition and they can be easily removed from them. This condition is noticed by pinching a thin piece of the bark and drawing it off the wood. If the bark peels off easily and if the exposed wood is mucilaginous one may be sure of the proper condition of the branch selected. This test holds good for rootstock plants also, for finding their suitability to receive the buds.

Budsticks are generally about six inches long and have three or more *unsprouted but well developed* buds on them. Sprouted buds and buds with thorns are unsuitable as they cannot produce any success, because while separating they almost always damage the germ or the growing point. If, however, a piece of wood is retained in the bud-shield, it is possible to use the buds containing thorns also.

As pointed elsewhere, bud-wood should be cut only from the best and heavy bearing trees of the most valuable strains that are known to bear fruits of the right quality. That a large number of trees even in the best of citrus groves are unprofitable, and planting of cent percent inherently heavy-yielding or profitable trees furnishes the best means of increasing the orchard income are facts that have long been realised by citrus growers in other countries. Hodgson (120) has shown that even in the most profitable orchards in California, approximately one tree in three is either only self-supporting or is actually grown at a loss. In the average orchard, the non-profitable trees amount to about fifty

ercent. Webber (326) has pointed out that in South Africa, ome groves are planted to trees almost quite worthless as comnercial sorts, and many trees are inherently low-yielders year fter year. In an experimental plantation raised with great care nd after repeated selection of individuals, Batchelor and others 14) have shown that inherent qualities of the tree is one of the nost important causes for variation in tree yields. Further vidence of the variations in trees caused among others by the ariations inherent in the buds due to heritage has been adanced by Webber in 1920 (337). These facts make it essential o carefully select the parent trees as sources of bud-wood.

It is best to use bud-sticks as soon as possible after they are ut. If it is necessary to retain them for some time; they should e wrapped in moist sphagnum moss and stored in a metal case vith closed lid in a cool place.

Bud variation and mutation

As a result of seed variation and changes appearing in the sonatic tissues of the plant, mutations or sports occur in citrus plants. Forms due to change of somatic tissue are known as "bud variation." In plants, improvements can be accelerated by careful bservation and isolation of desirable bud mutations. Conersely, the elimination of inferior bud mutations are of coniderable importance in propagation of trees from a fruit like some arieties of citrus which are especially subject to mutations. By uch careful selection of mutations and scion parents qualitative nheritance is assured, undesirable kinds are eliminated, the roduct is standardized and new strains are easily picked up.

The Washington Navel is a variety which is liable to bud ariation. Shamel and Pomeroy (237) in the United States epartment of Agriculture, who made careful investigations, ave shown by yield records that each variety in addition to its eing stable and constant in yield, is composed of several strains hich are capable of perpetuation through vegetative propaation. From individual records, they found that high-yielders ere always maintaining their hereditary nature of productivity nd that qualitative characters such as shape, taste and seedlessess are transmissible.

Some workers may not admit Shamel's accepted theory that e ribbed, corrugated, seamed or otherwise abnormal characrs noted on certain lemons and reproduced in progeny by

asexual propagation are bud-sports. According to son authors the tumor in Washington Navel considered by Sham as bud mutation is nothing but a disease of some sort of viru This can be transmitted by vegetative propagation.

In citrus fruits, Shamel and Pomeroy have listed 187 bu mutations in Washington Navel orange alone and 51 in Valenc orange (237). Webber (320) points out that Shamel's metho and principles of bud selection have been criticised by some i vestigators under the erroneous assumption that those principl and methods were based on the supposed continuous improveme made by selecting generation after generation from high yieldi trees. The main factor achieved by bud selection, which is no being done almost in every country is the greater certain that the trees produced from good selected mother typ will be more uniformly of the standard good type and mo productive. An instance of successful commercial introductio of a strain in Japan through the propagation of bud mutatio has been pointed out by Tanaka (277). Caryl (52) has pointe out that by means of bud selection, thorns have bee eliminated, late and early types have been separated, min varieties removed and quality improved.

Shamel's work has now received very wide recognition an numerous new strains propagated from a single bud taken eith from a limb or an entire tree variation are being extensivel popularised in most of the citrus growing countries. Sinc 1916, very few orchards have been planted, which have n been propagated from selected buds from inherently producti parent trees in California. Probably ten million buds have bee sold to California growers alone as a result of Shamel work. Two special strains produced recently—the Roberts Navel Orange and the Don grapefruit—are now being wide distributed, and seem to have great promise. In addition these benefits to the industry, Shamel's work has been of gre value in teaching growers to keep a close watch for branch mutating towards poor types so that they can be eliminated fro the orchard. Shamel's work has emphasised the importan of propagating only superior individual trees of outstanding me based on the yield records and other observations of at least fo or five years. Freedom from and resistance to disease should made a primary consideration in such work. Great care shou

also be taken to avoid propagation of limbs producing inferior bud-sports. Unintentional propagation of undesirable strains is bound to bring about a progressive deterioration in citrus orchards and it is, therefore, the duty of growers and nurserymen to not only preserve the best trees and look for more valuable ones, but also to prevent the multiplication of progeny from inferior bud mutations. Frost (91) believes that bud variation forms of citrus presumably originate in single cells, either by gene mutation or by differential mitosis. Variations also occur even among the apogamic seedlings, and this is considered to be due to chimerical conditions in the parent trees.

In the Presidency of Bombay, bud mutations have not been extensively isolated. But several clonal strains which seem to have originated by this process do exist in the cultivated local types of citrus. Examples of such clones are provided by the thick-skinned and thin-skinned *Mosambi* oranges. The round and oval types of limes, the *jamburi* and *id limbu* strains of lemons, etc., are believed to have originated as chance seedlings, as in the case of these fruits, vegetative propagation is rarely resorted to. A type of variegated lime has been isolated some time ago from a mutant branch of an ordinary lime tree. This branch had its leaves and even part of its stem variegated with yellowish and green patches all over. It was propagated by marcotte, and the progeny have retained the variegation. The new clone, however, is not of much economic value, as it is a shy bearer. In Madras one pinkfleshed Vadlapudi orange mutant has been detected and perpetuated recently.

Time for budding

Budding can be done with success at any time of the year in Bombay Presidency, when the plant is in growth. This generally happens when the cold season passes into spring and when the hot months are followed by rains. Buds inserted at other times take a very long time to sprout. Budding during rains is not advisable because the rain water might get into the wound caused in the rootstock during the budding operation and ultimately cause the tissues to rot. In that case no union of the bud is possible. It is considered desirable to have at least a week of clear weather after budding is done. In North India, the optimum period of budding for citrus trees is either February to March or August-September. At Kodur (Madras) it has been found that July to

end of December provides the best budding season. Buds inserted after January immediately preceding the hot weather failed to produce good growth. The seedling rootstocks may be brought into condition to receive buds in about a fortnight if so desired. The soil in the beds may be dug lightly and manured with farm yard manure and further given a light sprinkling of sulphate of ammonia. Irrigation should follow immediately. These treatments stimulate the plants to grow and come into flush within about a fortnight or three weeks. They can then be budded.

Lopping the rootstock

From the time of budding, the buds swell and sprout into shoots in about a month. If the buds remain green for a fortnight it may be taken that they are uniting. After a month the stock is headed off about 2″ above the joint so as to concentrate the sap on the scion bud. Sprouts coming up from below the scion bud are all nipped in the bud or rubbed off lest they make the scion bud starve. It is common among some Indian nurserymen to lop the rootstocks at the time of the budding operation itself. This, however, has been experimentally shown at Kodur (Madras) to result in a poor 'take' of buds and poor growth of bud-sprouts. In certain cases, it is seen that it is advisable to leave some nurse branches on the rootstock above the bud-joint until the bud sprouts and the sprout becomes strong enough to maintain itself, after which the nurse branch is lopped off. When the scion bud sprouts into a branch and grows to about a foot in length, the portion of the stock above the bud-joint is trimmed and cut close to the scion. The new sprout is then helped to grow erect by carefully tying it loosely to a stick or other support planted near the plant.

Transplanting

Nurserymen transplant budded plants when they grow well in the nursery beds. At Shikrapur, near Poona, where citrus plants are being raised commercially on a very large scale, transplanting of budded plants is invariably done in order to keep the growth of the tap root under control. If this is not done, the plants send their roots deep into the soil, and considerable difficulty is experienced in lifting them up for sale. The plants are transplanted in beds in specially selected shallow soils with *murum* below. In parts of the United Provinces and in the Punjab, transplanting

f budded plants is done several times to harden the root ystem, and to restrict the size of the roots to the narrowest mits possible. This naturally results in a considerable reduction n the weight of the plants and consequent reduction in the mount paid as railway freight and haulage charges. Often ne tap root is twisted and tied into a knot to meet the same nd. The knot gets fused together in course of time and remains nnoticed when the plants are sold, as the roots always remain overed with a ball of earth. When the plants are planted in neir permanent place in the plantation without disturbing the all of earth, the knots continue to remain intact. In course of ime, the knot hinders the proper and normal growth of the oot of the tree, and this may consequently accentuate die-back r other physiological troubles. The practice of knotting the oot, is, therefore, considered harmful and should be given up. Leading nurserymen are now realising the evil effects of this ractice, and adopting more efficacious methods to serve the same nd. According to these new methods, the tap roots are cleanly nd sharply cut at the required depth while transplanting. This elps them to develop lateral roots which do not go deep but nostly spread out in the upper soil layers of the bed. The roots levelop callus and the wound heals up well if the cut is neat. It s noticed that this practice is not as injurious as that of knotting f the roots, although definite experiments on the comparative nerits of knotting the root as against pruning it are not yet arried out.

Nature of buds and heir growth

In the nursery as well as in the plantations, attempt should be nade for obtaining a strong clean-stemmed plant of citrus, whether of *Santra* or *Mosambi* or any other type, by clipping off in the very beginning all the multiple branches, which might come up from he bud-joint or close to it. The buds of the *Santra* and *Mosambi* lants are almost invariably multiple, and as such, they give ise to more than one sprout. If the unsprouted buds of healthy ranches of these trees are examined, it is seen that in almost ll cases, two or more rudimentary buds are present in each xil of the leaf. They are not all of the same size. A transerse cut through any of them shows under a hand lens as nany concentric circles as there are buds. Usually one of these uds is bigger than the others. Normally, the biggest and most

vigorous bud alone seems to give rise to a sprout. Occasionall two or more sprouts may be seen to come forth from a single lea axil.

In the case of a single bud-insertion on a vigorous rootstock the inserted bud-shield naturally gets more plant food than i would on the original mother tree. Not infrequently, therefore such a bud-shield sends forth more than one sprout. To begi with, only one sprout may appear but later on when the root stock is headed off, more sprouts are seen to arise from the bas of the first sprout. This may be due to the extra food and sti mulus the other buds get. A count was taken of the sprout that came out of the original bud-shield in the case of fifty budde *Santra* plants, about one year after budding. It was seen from this count, that in many cases, the numerous sprouts that sho out gave a crowded and bushy appearance, with even eigh sprouts springing from a single bud-shield in some instances One or two of these sprouts are usually strong and vigorous the rest being weak and angular. These sprouts may appea one after another, and their appearance may be expected a any time in a young plant. The buyer of budded plants i led to believe that the larger number of sprouts indicates th superior quality of the budded plant. The nurserymen, therefore, make no attempt to allow only one sprout to grow from th bud. A clean stemmed tree is obtained only from a plant which has a single sprout growing from the bud. A clean stem is desirable for the following reasons:—

1. A clean stem at the bud-joint makes the joint strong and the tree becomes straight and shapely.
2. The bud-joint is most susceptible to gummosis and the clean stem facilitates treatment against thi disease by avoiding many inconvenient angles.
3. The stem borer is seen to attack grown up trees at th angles of the main branches, when they arise fron the bud-joint. A single clean stem gives them least opportunity and facilitates treatment wher there is an attack.
4. By allowing more than one sprout to grow from th bud-joint, the growth of the main stem is checkec and the plant becomes bushy, with many a weal branch.

5. A straight clean stem up to about three feet high makes cultural operations easy, and increases conditions of hygiene in the plantation. This is particularly so in the case of *Mosambi* and grapefruit trees, which have a tendency to give out low-spreading branches. The shock which the trees receive by cutting off a large number of their branches at one and the same time would be avoided by proper care in training the plants as required from the beginning.

Lifting of plants

At the time of lifting the plants from the nursery, care should be taken to injure the roots as little as possible. It is usual to dig out the plants with a ball of earth around the roots. The size of ball varies at different places, but usually has a maximum diameter of one foot. If the plants had been transplanted a number of times, or if the period of lifting synchronises with the dormant period, the ball of earth is reduced to the minimum size. It is observed that plants imported from South Africa, Australia and America during the winter months arrive with little or no soil around the roots, but in a greater part of this country subject to mild winter conditions, it will be risky to resort to this practice. It is only in Coorg and Wynad that mandarin plants are sometimes lifted and sold with naked roots. Practical defoliation sometimes accompanied by pruning of a few of the shoots, is done at the time of lifting in order to reduce the transpiration of water through the leaves. Complete defoliation is done by South African and American nurserymen when sending plants to this country.

Training

Training of the trees in order to have a strong frame-work is a point that requires attention at the time of tree-lifting. A modified leader system is considered to be the best for all citrus trees. According to this, only one leader or main shoot is allowed to grow, and all other shoots emerging from other leaf axils are considered subordinate to the leader. The secondary shoots should be placed in a spiral way around the leader shoot at suitable intervals. Violent pruning produces a large number of weak shoots or some tall and fast growing "sucker" shoots of not much value for the tree. Severe pruning of healthy and vigorous growing trees during the early years also tends to prolong the period

of vegetative growth and delays the bearing period and shoul therefore, be avoided. In order to secure symmetry an promote a strong frame-work, three or four secondary shoot may be selected, which should be distributed as evenly possible around the stem. If a shoot emerges immediately abov or opposite another, one of the two may be removed. Similar ly, crossing shoots are to be avoided. As pointed out above two or more strong shoots should not be permitted to gro from one place very close to each other, as this will result in th formation of weak crotches. Long and vigorous "sucker shoots should also be removed. Periodic inspection of the plo will be necessary to see that fresh growth does not occur fron unwanted places consequent to the pruning done at the tim of lifting.

Some authors recommend heading the young trees back i the nursery to twenty-eight inches to thirty inches above th bud-union. Three to five branches are suggested to b retained spirally around the trunk. If these are allowed t grow upright and the main limb allowed to grow uninterrup-tedly, it would produce a strong frame-work. The un-pruned trees, however, made better growth and became better trees from all stand-points. The subsequent performance of the former set of trees showed that early fruiting of the unpruned trees has had no apparent detrimental influence on the growth or behaviour of the trees.

Vegetative propagation of rootstock

Propagation of all citrus to be used as rootstock by seed is an almost universally accepted method. It is easy and renders the raising of a much greater number of vegetative progeny through the selection of apogamic seedlings than would be possible by any other means, without spoiling the mother tree. Further, new varieties can be imported through seed, thus minimi-sing the risk of importing diseases. Rooting of cutting of many varieties of citrus is also difficult. Halma (104) after an extensive trial admits that sweet orange and grapefruit cuttings root less readily than the lemon, but points out that by a suitable method they can be made to produce a satisfactory percentage of rooted plants. On another occasion, Halma (104) has stated that success in rooting citrus cuttings is achieved by taking cuttings from mature or semi-mature wood, and

pplying bottom heat and maintaining a high atmospheric umidity. In West Indies, some success has been obtained in aising rooted citrus cuttings in a solar frame, wherein the sun's ays are utilised to furnish heat to the beds (130). A few arieties of citrus have been propagated by cuttings at Lyallpur, hile some nurserymen in Madras usually raise orange plants y gooty and some lemons by cuttings. Since the root system f cuttings is shallow at least during the early years (114), and e propagation by this and gooty methods involves the removal f more material from the parent, and also because of the ossibility of certain diseases being transferred to the progeny om the parent trees, these methods, if used to raise rootocks, are not only uneconomic but may in fact be inadvisable.

Other vegetative methods of propagation have also been tried ith varying degrees of success in different parts of the world. Vebber (335) reports that layered trees were as productive and igorous as compared to budded or seedling trees. Enarching as also been practised to provide a new root system to old itrus trees that have damaged roots by planting one or more eedlings near the collar and inserting the wedged ends of ese stocks to the base of the scion trees. Ringing of hardood cuttings of some citrus trees for the production of roots as also shown to be possible by Hunter (131). He has also hown that the relative spread of root formation in stem propagaion is a specific attribute. Semi-hard wood cuttings of citrus re propagated with much more certainty than those of hardood.

election of site
nd spacing

After selecting the site for raising an orange plantation, iving due consideration to the soil, climate and irrigation facilities, for which purpose the advice and help of an expert may profitably be sought in the beginning alone to avoid loss and disappointent later on, the land is first ploughed at least twice crosswise. everal thorough harrowings are then given and if time permits, e area may be left fallow for a season, and then sown to nn hemp (*Crotolaria juncea*) which crop should be buried in e ground as a green manure. If the land is required in the ld season, it can be brought into form in the following summer nd green manured during the ensuing monsoon. The next ot weather may be utilised for taking pits at the required dis-

tances, and planting may be undertaken in June at the break of rains. If this is not possible the land may be ploughed and harrowed, and pits may be taken and left exposed during the hot weather for about two months. Planting may be taken up in the following June, in which case a full year is saved.

An appropriate spacing will depend upon the individual characteristics of the varieties selected and rootstock employed and their responses in respect to root growth. The penetrability of the soil has of course a marked influence on the rate of growth of the roots, but despite this fact varieties differ markedly in their spread and depth of root system. Until recently, the belief was common that the spread of roots corresponds nearly to the spread of the branches. A year old budded orange tree on a certain rootstock variety at Kodur (Madras) has been found to forage over a length of six feet radius from the trunk, whilst the spread of its branches hardly reached a radial length of one foot. In bearing plantations also, roots have been known to extend several feet beyond the branch spread. Till the root system of citrus trees on different rootstocks are studied under varied soil conditions, it is not possible to recommend definitely the optimum spacings for all the fruits.

The first principle underlying the spacing of fruit trees would be that the trees are to get enough growing space so that their branches just come into contact when they are of middle age. The habit of growth of trees, therefore, plays an important role in deciding upon the space to be given while planting. *Mosambi*, pummelo, grapefruit and Navel orange trees which have a spreading habit, are generally planted 20-25 feet apart. Trees planted fifteen or even eighteen feet apart are seen to overcrowd themselves in the Ahmednagar and Khandesh districts. Similarly, the practice of planting them at a distance of twelve feet each way necessitates the removal of the plantations very early, that is when they are just about ten or fifteen years of age, as is noticed in the Saswad (Poona district) tract. It is, therefore, better and more profitable in the long run to allow at least twenty feet each way for these fruit trees. *Santra* trees which have an erect habit of growth are ordinarily planted at a distance of fifteen feet each way in Bombay Presidency. Such trees are seen to overcrowd themselves when they are advanced in age. If the soil be well drained and loamy, even *Santra* trees may be planted twenty feet

part. In fertile soils under favourable conditions of climate nd culture, even 25 feet spacing has been noticed to be scarcely dequate to citrus fruits. The *kagdi limbu* (lime) trees are also lanted at eighteen to twenty feet apart in Bombay Presidency. the soil is well drained and fertile, the trees may be profitably iven an additional spacing of two to five feet each way. If on ne other hand, the soil happens to be medium clay and rather icky, the usual spacing as mentioned above may be adopted.

The spacing given to citrus trees varies markedly in the rest f India. In the Punjab, the general rule is to allot a twenty feet pacing for all kinds of citrus trees, but in the South of India here seed propagation is widely adopted, twenty-five to thirty et spacing is given to sweet orange and *Santras*, and eight to welve feet for acid limes. Recent experience at Kodur and lsewhere shows that 24 feet for budded sweet orange and 22 feet or acid lime are perhaps the best in South India.

Pits are best taken in the hot months and kept open until the llowing rains. Pits of three feet by three feet by three feet are usually taken for all citrus trees at the distance decided upon, as explained above. While igging the pits, the upper half of the soil is commonly heaped eparately, and both heaps as well as the interior of the pits are xposed to the weathering action of the sun and wind during the ot months. Just before the rains are expected, the pits are filled p with the upper soil going first into the pits and the lower soil oming upon it. Both heaps of the soil are sometimes well mixed eparately with the following mixture of manure per pit while lling the pits.

Pits

- 5 lb. bonemeal (or 10-20 lb. of whole unbroken bones),
- 100 lb. (about 4 baskets) of well rotten and powdered cattle manure, and
- 10 lb. of ordinary wood ash.

When the pits are thus filled a small peg is driven into the centre f each of them as a mark to guide the planting operation, hich will follow after some days. Pits must necessarily be lled before the rains start, lest they get stagnated with water nd their improved structure is spoiled by rain water. As ointed out for mangoes, it is suggested that no manure of any ind need be added to the pits in fertile soils. In other soils also,

it is best to allow ample time for the manurial ingredients t decompose in the pits prior to the actual planting. Addition excess manure, or fresh organic manure to the pits at or ju before the planting of trees is a practice that requires to b discouraged.

Planting

Healthy and vigorous budded plants are brought from com mercial nurseries for planting, which is done when one or two rai moisten the soil and cool down the atmospher Arrangements may be made in time with reliab and registered nurserymen to reserve the required number plants of high quality and they can be obtained just in time fo planting. There is a widespread belief among the people th large-sized plants are preferable for planting and will bear frui in a relatively shorter period. Very large and old plants, n only cost more to the grower, but also a large percentage of the suffer both in the orchard after planting and during transi Webber (331) has shown that larger seedlings no doubt produ larger budlings, but it has to be remembered that the differen in the size of plants disappears rapidly as years roll on, and found to remain only upto about eight years.

When plants arrive, they should be taken delivery of witho delay and planted out in the field directly. While plantin each plant should be separated from the rest carefully, witho damaging roots or shoots, and all injured roots and tender shoo neatly pruned off. Planting is done in the centre of the pi where the peg was driven previously by removing the refill soil out just to accommodate the roots of the plants in the normal (not twisted or contorted) position. The soil then put over and around the roots and pressed well with th feet of the planter. The plant should not be set down deep so as bury the stem. It is a serious mistake to bury the bud-joint wh planting, as this predisposes the trees to the attack of white a and gummosis trouble later on. The bud-joint should be ke high above the zone ordinarily made wet by the irrigation wat in order to prevent the attack of gummosis at the bud regi Irrigation is given copiously immediately after planting. T tender plants are protected for a few weeks after planting fr the heat of the sun by shading them with some kind of shel made of green branches or so. These are removed after t plants revive from the shock of transplanting. In Rah

BASIN SYSTEM OF IRRIGATION IN A YOUNG CITRUS ORCHARD.

Facing page 173.

Ahmadnagar, Bombay State), *Mosambi* plants are sometimes lanted in lucerne fields where they get ample water and manure nd ample shelter from the sun's heat to start their life. After ne plants establish themselves, lucerne growing is discontinued. n ill-drained fields this practice may be harmful, since the trus trees may find that water applied to lucerne is much more n quantity and frequency than required to suit their needs.

In North India where there is a definite dormant period uring the winter season, planting is done either in February or Iarch, as soon as the severity of the winter weather shows signs f decline, or during August-September soon after the rains comence and well in advance of the cold season. In South ndia there is a longer planting season, commencing in July and ntinuing up to the end of January. Planting trees in ebruary immediately before the ensuing hot weather is not esorted to.

rrigation

After the first copious irrigation given immediately on planng, a lighter watering follows in four or five days. Thenceforth, irrigation is done in regular turns. If the area is under well irrigation, water is given once six to eight days in the hot months from March to June, and nce in ten to twelve days in winter from November to February. uring the rains, July to October, water is given only when there a long break of rains. But where irrigation is from the canal, ne canal regulations cannot be changed to meet the requirements f orange plantations only, and the grower, therefore, irrigates is orchard whenever the authorities allow the canals to run. here is no doubt that this system does cause considerable innvenience and loss to the grower, and in the best interest of e industry, the irrigation laws require to be changed to suit e needs of the planters wherever feasible. In canal areas, ving to the uncertainty of the availability of water, growers ten let into the orchards as much water as they can when water available, as the next turn of water may be uncertain and irgular. This practice often causes periodic stagnation of water the soil, and brings about die-back and root-rot trouble. o heavy irrigation is as harmful as lack or inadequacy of ater. It is, therefore, safer to have well irrigation, as it n be controlled by the grower himself. Well irrigation is ecially preferred when trees are treated for crop and when

quantity of irrigation water to be applied has to be regulate Plantations of citrus get badly damaged in canal irrigated trac where they may be surrounded by heavily irrigated crops li sugarcane or rice. The percolation water of the neighbouri fields enters the citrus orchards through the lower layers of s and always stagnates at the root zone. This situation preve soil aeration and proper functioning of roots, as a result of whi the trees suffer.

The practice of irrigating the citrus groves in this count has, in general, followed, certain arbitrary rules, especially regard to the frequency of application and the amount of wa applied. Most of the best kept orange orchards in the Unit States of America report average water usage of sixteen twenty inches per annum. Some authors report that, California, 9·2 acre-inches of water are used for Nav ranges from April to October, which in most years cons tute the main irrigation period in that State. It has be suggested that alternate medium and light applications of wat with not more than two heavy applications a year, would be t most efficient irrigation practice in Arizona. Thomas (30 states that as much as sixty acre-inches per acre have be applied in one irrigation season in some parts of Californi This, however, is very rare. He avers that citrus trees a more sensitive to an excess of moisture than some other crop The trees especially on heavy soils may get stunted due to e cessive irrigation. Even in a grove where only seven applicatio for the season with a total of 18·5 acre-inches of water we applied per acre, he has pointed out that a considerable part the water applied penetrated below the reach of the roots, carr ing soluble plant food with it. He states that on heavy loa soils, a sixty-day interval resulted in better root developm and more uniform distribution of soil moisture. Transpirati of trees averaged 16 inches in orange county while in the terior climatic zone of San Bernadino and Riverside it v 21 inches for excellent and good condition trees. Transpirati will vary from 50% to 80% of the total irrigation applicati (197).

Veihmeyer and Hendrickson (313) point out that on sa loam soils of four to six feet depth in north Sandiego cou the interval between irrigation during summer should

exceed forty-five days, while in the lighter types of soil in orange county, the interval will range from thirty to forty days, and on the loam soils from forty to forty-five days. About one to one and a half times as much water was required when cover crops were grown as when the orchard was given clean cultivation. It is observed that citrus roots are most dense in the upper three-feet layer, and the upper foot contains the large majority of the roots. Thomas (306) states that citrus roots seldom penetrate below a depth of four feet. In soils less than three-feet in depth, it is estimated that fifty to sixty percent of the roots are in the top foot of the soil. The soil should be wetted at each irrigation to the depth in which most of its roots occur, even though the lower layers still contain some readily available moisture.

It is, therefore, clear that citrus trees develop a relatively shallow root system in most soils. Since plants will withdraw moisture from a given soil mass in proportion to the quantity of active absorbing roots in different depths, other conditions being constant, a knowledge of the rooting habit of the plant is useful in any intelligent soil moisture programme. In Arizona, grapefruit trees of four years of age on a light-texture soil had developed eighty percent of the total root system in the surface two feet of soil (240). In another study with mature citrus trees on the same soil type, where the extreme depth of root penetration was in the ninth foot, the major part of the root system was quite shallow. Another study in Arizona revealed that sixty-five to seventy percent of the absorbing roots of mature citrus trees are located in the surface two feet of soil (111). The same investigation shows that 31·6 acre-inches of water are applied in Arizona to Navel ranges in a year, and 40·7 acre-inches to grapefruit. Smith, Kinnison, and Carns (240) report that about thirty acre-inches of water per annum is applied to grapefruit trees on the Yuma Mesa in Arizona. Irregular watering or rainfall interferes with the normal growth and production of the trees. It has been observed that under moist conditions, in central and south India whenever trees are subjected to heavy rain, after a period during which water has been withheld, a flush of blossom results which may interfere with the fruit set in the normal season.

The most important methods of irrigation employed in citrus orchards, and in fact, in all fruit plantations are flooding, check

method, basin, ring and the furrow. The flood method consists of applying water all over the surface of soil. It is only possible on level ground and where water supply is abundant. It is obviously a wasteful method in young orchards, where the whole area is not occupied by the roots. With the check method, water is held around trees for a time by suitable bunds to induce percolation. This is a popular method of irrigation among the orange growers of South India. Bunds are run between every two rows of trees, with cross bunds at right angles to these so as to form a basin covering the entire area reserved for each tree. It has no place in young plantations, nor where cover or green-manure crops are raised. The preparation of beds entails much labour and where it is practised, it is intended to be a permanent feature not to be replaced or changed within short intervals.

Systems of irrigation

The basin system is perhaps the best method of irrigation in young groves. Small basins are prepared with bunds a little away from the drip of the young trees and these are connected with irrigation channels. The basins are widened gradually as the trees grow. Since investigations have proved that the lateral root extension of a tree is far beyond the spread of branches, it is necessary to make the basin larger by at least two feet than the tree-spread. On slopes, basin irrigation has special uses, since it facilitates control of water and retards the drift of silt from the upper to the lower regions. Such soils as may be moved are not lost, but tend to bank up at the lower end of each basin, ultimately creating a terrace-like effect and thus enabling more effective control of the water. This is so in the check system also.

The ring system is also recommended for young plantations, in areas which are likely to be affected with gummosis and other stem maladies. The ring method consists of making a small raised mound of earth near the trunk of trees, and by the outer side of this mound a ring about two to five feet in width with an encircling bund are made to hold water. Irrigation channels are connected to the rings by short furrows if necessary. Water is thus kept away from the trunk of trees, while it feeds the roots at their main feeding zones. The rings are widened periodically as the spread of the trees increases. The mound of earth near the trunk is also increased in spread but not in height. When the

tree-spread is so advanced that branches of adjacent trees touch, the rings give way to check, flood or furrow methods.

In South India a modified basin method is also sometimes known as ring system. In this, a circular bund is formed around the tree trunk, 2 to 3 feet away. Beyond this bund is the basin, which receives the irrigation water. This method does not seem preferable to the basin system, where a gentle slope is provided from the stem to the periphery of the basin, so that when water is let in, it first fills in at the periphery and remains there longer than towards the trunk. If the periphery is about four to five inches lower, water may not touch the trunk at all, or if it does, it will not remain in contact with the trunk for long.

The furrow method is very extensively practised in some citrus growing countries of the world. By this the entire soil surface is not wetted, and an even distribution of water ensured. It is suited to level or very slightly sloping areas. Four to eight or even more furrows are made at equal distance between the tree rows, with a double mould board plough or bund former. The water is admitted to the furrows from a main feeding channel. Water applied thus in furrows tends to move downwards with little lateral movement, the maximum lateral movement having been found in California to be about thirty inches from the centre of the furrow. The length of the furrows should not be too great, as otherwise moisture penetration is not satisfactory. On hill slopes, furrows exceeding 250 to 350 feet are considered undesirable.

Although four to eight furrows are ordinarily made between every two to three rows, additional furrows are also often zigzagged. In young tree plantations, two furrows one on each side of the row are also recommended in some parts of the world for four or five irrigations. But a combination of furrow and flood irrigation methods is suggested where there is any objectionable salt or alkali present in the soil.

Manuring citrus orchards judiciously is of very great importance in India. Enough experimental results on this subject have not yet been recorded to suit local conditions. However, from the general observations on the requirements of the plants from their early stages of growth, it is surmised that young plants need more of nitrogenous manures than bearing ones. In the earlier stages, that is, up to

Manuring

the age of five years, the plants grow well vegetatively, and establish a proper root system and head. This is accomplished by the supply of nitrogenous manures which help the trees to develop a rich green colour and healthy growth. Phosphatic and potash manures should be given some prominence, though not by any means to the exclusion of nitrogenous manures after the trees come to bearing. Potash manures produce a balanced growth, maturity of shoot and fruits and help the formation of sugars and starch in them. Phosphatic manures stimulate bearing of fruits and promote root development and hasten maturity of plants.

No manure is given to the plants until one year from planting in the orchard except what may be given to the pits while or preferably before planting. A one-year-old plant may be given 20 lb. cattle manure, 3 lb. wood ash (for potash), 1 lb. bonemeal (for phosphoric acid) and 2 lb. of some kind of oil cake (for nitrogen). This dose of manures may be increased by equal doses year after year until the plants are five years old. After that the oil cake may be reduced to five pounds only per year, the other doses remaining constant at the five-year dose throughout. In tracts where there is white-ant trouble, the oil cakes should be substituted by sulphate of ammonia or restricted to castor and *Karanja* (*Pongamia*) cakes only. These cakes are believed to deter white ants, being bitter and possibly also partially toxic to insects.

A good deal of literature on manuring of citrus trees is available regarding experimental work carried out in foreign countries. In many cases, the three manures already mentioned are given prominence and the doses are adjusted to suit the soil conditions. In cases of mottled leaf and lack of chlorophyll in the foliage, a zinc sulphate-lime mixture is sprayed on citrus trees one or more times. Copper sulphate in Bordeaux mixture spray is also sometimes applied in light doses to overcome the die-back or exanthema trouble in certain soils of Australia. A small dose of ferrous sulphate may also be given with advantage to correct iron deficiency, wherever that is suspected. Magnesium sulphate is yet another fertilizer found useful in some soils as those in parts of Florida. Lime and manganese applications too have a value under certain soil conditions.

The amount of soil nutrients removed from a good crop of oranges (about three hundred boxes per acre) has been estimated to be 43 lb. of nitrogen, 12 lb. of phosphoric acid and 49 lb. of potash (14). The latter two are less subject to loss by leaching than nitrogen, while the loss of organic matter was found to be very rapid. In humid regions, the loss is more than in semi-arid or arid regions. Again, since the roots of citrus are most dense in the first three feet of soil, greater depletion of soil nutrients occurs in this top layer than in others. In California, large increase in productivity of as much as 43 per-cent was obtained when only a small amount of fertiliser containing half a pound of nitrogen was applied in conjunction with a cover crop incorporated into the soil during winter. Batchelor (14) considers that in California, it is an extravagance to apply nitrogenous fertilisers more than once per year, and Webber (320) supports this view. No measurable effect was seen in California by the applications of potash and phosphate fertilisers.

Analytical data on nitrogen content in 36 bearing Valencia orange trees excavated over a two-year period at intervals of 3 weeks, reveal that nearly half the nitrogen is in the leaves, about one-tenth in the twigs and shoots, a quarter in the branches and trunk—about half of this being in the bark—and rather less than one-fifth in the roots. A maximum nitrogen content occurs just prior to the initiation of new growth in the spring and a minimum in mid-summer (50).

On the basis of a very comprehensive experiment with fourteen different fertiliser treatments on 2500 Washington Naval trees in South Africa, Anderson (7) has shown that a balanced nutrient solution with nitrogen and phosphoric acid is of the greatest importance. Ammonium sulphate induced very marked increase in weight of crop and number of fruits. A leguminous cover crop did not produce an increase in the nitrogen content of the soil or in the size of crop. Similarly, superphosphate, potassium sulphate and lime did not affect the size of the crop. High potash content caused high acidity in fruits, while a high phosphoric and calcium content in soils produced the reverse effects. The thickness of rind of oranges was increased by high potash content and decreased by high phosphoric acid. Except nitrogen, none of the elements

had any effects on sugar contents. Lord (156) advances t
suggestion that a judicious increase in lime application
citrus groves is beneficial. In Florida, the citrus produced
soils of high lime contents has received consistently better pric
than the rest. Ground lime stone screenings, wood ashes a
raw phosphate rocks may furnish valuable sources of lime. V
bury and Robinson (314) state that excess of nitrogen results
die-back and also causes thick-skinned and puffy fruits. Stab
manure, on the other hand, may have a bad effect especially
trees growing on light soils when applied in large quantiti
In small quantities, it is considered to be the best for citr
trees. On heavy soils, rich in humus, the application of li
is said to be beneficial, but too much of it may injure t
soil. Withholding of potash has been shown to reduce t
size of fruits in New South Wales (22). A mixture contai
ing six hundredweight of sulphate of ammonia, three
superphosphate, and one and a half of sulphate of potas
applied at the rate of one pound of the mixture per tr
for each year of tree's age till about the seventh year, when
would receive seven pounds, has also been suggested by som
authors.

In South Africa (166), manures made from crop residu
are recommended to be applied to trees at the rate of 200 l
per annum per bearing tree or about eight tons per acre. But th
exclusive use of this manure as an annual dressing is consider
inadequate, and therefore, has to be supplemented by ino
ganic nitrogen application. On the other hand, five to te
cubic feet per tree of good stable manure or its equivale
in other organic fertilisers is reported to have given exce
lent results in some cases. Organic fertilisers, such as guan
showed no positive advantage over purely inorganic fertilis
mixture. Inorganic forms of nitrogen appeared to be part
cularly useful in revitalising declining trees. The value of th
application of nitrogen and organic matter to citrus trees i
South Africa as in California is also emphasised by Blatt (38).

Citrus growers in Western Transvaal are recommended t
apply 150 to 200 lb. of well rotted *kraal* manure in June or Ju
per bearing tree per annum. For Navel oranges an add
tional application of five pounds of sulphate of ammonia is r
commended to be given in July together with ten pounds of supe

phosphate to large seedling trees, and somewhat less to fully bearing Navel and Valencia trees. Potash is advised to be applied in an inorganic form (5). Much of the nitrogen is to be applied during the spring, while a light dressing of nitrogen with phosphoric acid and potash during autumn is said to assist in maturing the autumn crop and future fruit-ng wood and benefit the crop (59). Prest (201) suggests that a uitable annual fertilising dosage for mature lemon trees would e six hundredweight ammonium sulphate, four of phos-hatic fertiliser and two to three of potash fertiliser. Twenty ons of farmyard manure may also be applied per acre, or ailing this, a green manure may be grown.

Some of the orange growers in the Rajampet taluk of the Madras Presidency apply a mixture containing 12 lb. ground-ut cake, 9 lb. of fish manure, 3 lb. bone meal, and four to ive baskets (100 lb.) of well rotted farmyard manure per tree er annum.

Growing and turning under of green manure crops are neces-ary where bulky organic farmyard manure is not available in ufficient quantities. This practice is of special value in young lantations, as it aids in the building up of a reserve of vege-able matter in the soil. Griffith (99) reports that in New South Vales, green manuring with a legume crop sown in winter in-reased the citrus crop yield by 33 percent. It was also found hat although citrus trees did not respond to superphosphate, it is ecessary to apply this fertiliser for securing a good growth of reen manure.

It has been shown in Arizona, that the fruiting behaviour of trus is more closely associated with the nitrogen supply during e winter and spring months than with any other nutrient aterial (9). Supplementary applications of nitrogen are re-rted to reduce shedding of fruits and increase the yield while avy quantities of organic manures (20 tons per acre) are said produce larger and somewhat coarser fruits and also to delay aturity. Nitrogen-starved trees produced fruits which coloured rly and had a low acid percent, but the rind was thick and e juice content low.

Recent work in Holland has demonstrated that the amounts vitamins C and A produced by plants largely depend on the nounts of nitrogen and potassium added to the growing

medium; increase in nitrogen in the medium being responsib for an increase in vitamin C and A while increase in potassiu produced an increase in vitamin A and decrease in C. Suc responses were, however, not obtained in America (83). The is enough justification for the belief that different manuri treatments bring about different effects on the quality of fruit and as such, the subject is of great importance both for th grower and the consumer alike.

The furrow method of application of manures and fertilise became popular for a time in some parts of the United States America. The manure or fertiliser is distributed in furrov eight to fourteen inches deep running alongside the tree The furrows for the first season may be run along both sides the trees near the drip of the branches in the same directio as the flow of irrigation water. In the second season, the may be located similarly but at right angles to those of the fir year. In the third year, the furrows may be made parallel those of the first year, but nearer the centres of the tree row and similarly they may be placed the fourth year parallel t those of the second year. In later years, the methods c application depend upon the circumstances.

The application of manures in the Bombay Presidency done at the commencement of monsoon in the case of youn trees. When they come to bearing, the manures are applie while the trees are treated for bearing, by withholding irrigatio and exposing their roots to induce flowering, excepting the nitr genous manures which are best applied when fruits are set. Th adjustment in applying manures coupled with frequent stirrir of soil, helps the fruits to develop into large size and to becon very juicy. Nitrogenous manures applied together with othe while the trees are treated for flowering, are noticed to hind flowering and to encourage vegetative growth. Slaught house refuse when applied at the rate of two baskets (30-40 ll per tree of *Santra* and *Mosambi* of three years of age has be observed to produce good effect. One of the profitable resu obtained was also by the application of 4 lb. of ammonium s phate plus farmyard manure, the latter being essential to enal the trees to make full use of inorganic nitrogen supply (151).

In Rahuri (Ahmadnagar, Bombay State), *Mosambi* trees a manured at the rate of 5-6 lb. of castor or *karanja* (*Pongamia*)

A YOUNG ORANGE GROVE WITH A COVER CROP OF HORSEGRAM. *Facing page* 183.

ake per tree of fifteen to twenty years of age before blossoming. 'his stimulates flowering and fruiting abundantly, specially in ld trees. Farmyard manure is also given at the rate of two to our baskets (40-80 lb.) per tree.

Grove culture

Proper cultivation of the soil in citrus groves is as much ecessary as in other orchards for providing an adequate soil aeration and also to prevent the weeds from robbing the soil of moisture and nutrients. 'roper cultivation renders more water available to the roots y increasing the pore space and materially diminishing resisance to the rate of flow through soil. The extent of cultivation equired to be given to an orchard is dependent on the soil toporaphy and also on the kind of inter-crops grown. Removal of veeds, however, forms the main object commonly kept in view, ut recent experience in the United States of America is that he weeding operation is usually overdone in most of the groves. t is not sufficiently realised that in some locations weeds serve s soil binders, by checking erosion and drift of the surface soil eyond the range of trees. That weeds can be utilised to the dvantage of the trees by ploughing them under the soil and llowing them to decompose into soluble humus is also a point ot to be forgotten. The old idea that the presence or absence f weeds is a measure of the citrus grower's ability is being disodged, and the harmful effects of continuous clean cultivation s being increasingly realised (67). In many orchards, weeds erve as a voluntary cover crop and a worth-while addition to rchard soil. Realising their value, American citrus growers re now discarding the erstwhile practice of clean cultivation to e modified methods of giving the minimum cultivation that is ecessary to incorporate weeds into the soil, except when interops are raised. Deep tillage is likely to damage the roots of ees and should be resorted to only in young plantations. Connuous grove cultivation may result in the formation of hard an or plough-sole, destroy the organic content, decrease bacrial life, and hinder the proper root penetration. Deep culvation is necessary in young plantations where there is no fear f root injury, but should on no account be resorted to in older lantations, especially just prior or just following the blossoming eriod. Stirring the soil when wet, spoils the texture and reards the movement of water.

The orchard is ploughed or disced in the spring to i corporate the cover crop or weed growth with the soil. Tl soil thus made available is used to construct irrigation furrow If rains occur before the first irrigation, or if there are plen of weeds, it may be necessary to cultivate once again. In son orchards, cultivation is done once after the first irrigation bu this is not done in all cases. The original furrows are le for several irrigations, if water supply costs less than remov of weeds. The orchard is cultivated and smoothened before ha vest. Clean cultivation in dry season, combined with cov crops during the summer and rainy season, is the most widel used system in Florida (314). In Palestine, two hoeings p year (196) are considered indispensable to a citrus grove, o in the spring prior to the blossoming period (particularly i heavy soils) to aerate the soil, and another in autumn in orde to hoe in the organic manure. In the United States of Americ the trend is decidedly towards less frequent stirring of the soil.

During the first three or four years of a citrus plantatio there is generally ample space between the tree rows to perm

Inter-crops

of raising subsidiary crops of some kinds c vegetables or of other crops of short duratio Such crops as *guar* (*Cyamopsis psoralioides*), *Bhendi* (*Hibisci esculentus*), cabbage, knolkohl, cauliflower, tomato, and brinj (*Solanum melongena*) are preferred for growing as inter-crops i orange and allied orchards. These inter-crops finish their lif cycle in about five months from the start and may be grown eithe in the monsoon or winter. They do not require heavy and co tinuous irrigation. The land is left open for part of the yea which is highly desirable for proper hygiene of the land. Thes crops are of considerable economic importance, as they help th grower to meet sundry expenses as for example to pay for labou manures, feeding cattle, etc. During the first few years, ther fore, when the main plantation does not bring any return inter-crops are dependable to some extent for their income. I dry parts of the Bombay Presidency like Bijapur and in th East and West Khandesh districts, orange plants are sometim planted at the required distance along with the plantations banana. A dwarf short-lived type of banana, namely, the *Basra* is grown in these districts, and citrus plants get the advanta of being protected from the scorching sun during the first tw

years of their life, if planted in banana plantations in these tracts. The banana plantations are removed within two years after citrus plants are planted and the latter are fairly well established by then to stand exposure to the natural heat of the tracts.

Inter-crops in citrus plantations should not be such as would require heavy irrigation and would occupy the land throughout the year, because the irrigation given to such inter-crops makes the land oversaturated and the main plantation suffers therefrom. Crops of lucerne (*Medicago sativa*), sugarcane and banana should be avoided as inter-crops as far as possible. Of course, the extremely hot tracts like the Bijapur and Khandesh districts are exceptions; and growing of such inter-crops during the first two years of the life of citrus plantations in these districts may at times be a desirable feature. Owing to the hot winds that blow during summer and the high temperature of the atmosphere, the effect of heavy irrigation to banana is not felt by the citrus plants. On the other hand, the latter are properly protected.

Pruning

There exists a lot of controversial matter in regard to pruning of citrus trees. One of the objects of pruning citrus trees is to give the plants the desired shape. Hodgson (119) believes that with practically all varieties "a certain amount of training" is necessary, if proper framework formation is to be secured. During the first two or three years special attention should be given to the selection of the framework of the trees as has already been pointed out previously. He recommends that three to four main scaffoldings be selected and these should be distributed as evenly about the trunk as possible. If they are selected early, and those not required are pinched or thinned, it is not necessary to head back these main leaders. When the frame-work branches are established, the only pruning that is necessary is the removal of suckers and the unusual vigorous water sprouts. He suggests that a good rule to follow especially in the pruning of young citrus trees, is when in doubt, leave it alone unpruned. During the first few years of bearing, pruning should be confined to the removal of suckers. Later, thinning may have to be done. As the trees grow older, it may be necessary to provide for the gradual renewal of the bearing area by occasional removal of older parts; but this must be done gradually. The lower branches bear fruits of poor quality

and therefore should be removed, but the tree should not be pruned too high. A foot from the ground is all that need be kept free from branches.

Ringing

In South Africa, ringing of citrus by giving a single circular cut knee-high round the trunk, through the bark to the wood just before the last petals of the main bloom have dropped gave substantial increase of yield. The greatest increase occurred only when low yielding or shy bearing trees had been girdled. Shamel and Pomeroy (237), however, noticed in California, a marked reduction in yield of previously ringed trees in the season after ringing. Little effect on yield was observed during the ringed year except during light cropped years.

Growing and fruiting seasons

Santra and *Mosambi* trees exhibit three growing seasons in the Bombay Presidency. They are June-July, September-October and February-March. The trees put forth new growth in each of these seasons, and often bear flowers and fruits indiscriminately in all of them, if they are left to nature. In order, therefore, to take advantage of the markets which are active in particular seasons, the orange growers of the Presidency give certain special treatments to the trees and make them bear only one but heavy crop in the year. The flowering seasons are called "*bahars*" locally. The purpose of these treatments is to check vegetative growth and to stimulate flower bud formation.

There are three *bahars*, for any of which the trees may be treated during the year. They are called the *Ambe* (February-March) *bahar*, the *Mrig* (June-July) *bahar*, and the *Hasta* or *Hatti* (September-October) *bahar*. The trees are usually treated for only one of these *bahars* in any tract, and to change the treatment from one *bahar* to another is a matter of considerable difficulty and inconvenience to the growers and also injurious to the trees themselves.

Treatment for *bahar*

When the orange trees are in their fifth year, they are generally treated for the crop for the first time. Flowers and fruits that may set earlier than that age are carefully removed before they develop, lest the early bearing should weaken the young trees.

The treatment for the *Ambe bahar*, so named because the flowering coincides with the flowering of the mango (*Ambe* or

ROOT EXPOSURE OF MOSAMBI ORANGE TREES.

Facing page 186.

ROOT EXPOSURE, SHOWING ROOT SYSTEM OF *SANTRA* TREES.

Facing page 18

mb trees) consists of withholding irrigation water for about vo months from the beginning of November to the middle of anuary. Irrigation is gradually reduced in the plantation by ssening the quantity of water given in each turn. The turn watering which falls in the first week of November is half of e normal dose and the one that follows it is about one-third. rom that turn irrigation is completely stopped. When the soil the orchard dries up, the trees show signs of wilting and the aves are shed. About the middle of December, the land is oughed and harrowed. All dry shoots on the trees are pruned nd the whole plantation is cleaned. If the trees do not show nough signs of resting by stopping water alone, as it often appens in heavy soils, the upper roots are exposed by removg the soil all round the trunk to a distance of three feet and to depth of eight inches. The finer roots that get exposed in this ea are neatly pruned close to the larger ones and any wound used to the latter is trimmed and coal tar (liquified and oled) is applied to it to prevent rotting. Roots half-an-ch or more in diameter are not pruned. This works as an lditional check on the feeding of the trees, and stops their getative growth remarkably.

The roots are kept exposed for about ten days. The original ii is then replaced after mixing it with the annual dose of anure (excepting the nitrogenous manures as explained above) d the roots are covered up again. Water channels and basins e prepared and irrigation begins from about the middle of nuary. The first watering is very sparing, the second which given after four or five days is more copious, and the third tering which follows ten days after the second is a full dose. rmal irrigation continues from then onwards. This precaur is essential because heavy irrigation all at once tends to ce up vegetative growth. By the middle of February, that is, about a month from the first watering, new shoots appear on ich flower buds are seen. Flowering may continue till the ddle of March when fruits set. Early in June, a dose of nitronous manure (oil cake as suggested above) is given to the es and the soil in the basin is stirred frequently to keep the eds down and to help the fruits to develop. In the loose, sandy ep soils of Rahuri, no root exposure is found necessary to ince flowering of *Mosambi* trees. Withholding irrigation for

about a month brings about the desired effect to check the vege tative growth of the trees. Trees of thirty or forty years of ag are very common in this area and are seen in good health capabl of bearing a good crop with normal irrigation and manuring Older trees do require more manure than younger ones for bear ing properly.

Fruits of *Ambe bahar* become ready for harvest in Novem ber-December, and the season may extend upto January an even to February. During Christmas the demand for orange is fairly active and growers, therefore, take advantage of it.

Treatment for the *Mrig bahar* commences from April whe irrigation is decreased gradually and stopped altogether by th end of that month. From the middle of May, the land i ploughed and harrowed and roots are pruned in the same way a in the case of *Ambe bahar* treatment about the end of May. B the middle of June, trees are manured and water channels an basins are prepared and the first water is given immediately unless it rains by then. The operations are hastened up if signs o approaching rains are strong. First irrigation is sparing, th second is more copious and the third watering is a full norma dose, provided in all cases, rains do not intervene. By the middl of July, flowers are seen and fruits become ready for harvest i March of the next year.

As the fruits of this *bahar* are raw and acidic during the mon soon months when the *ophideris* moth breeds well, they do no suffer from their attack as much as *Ambe bahar* fruits do. Durin the months of March, April and May, there is always a goo demand for the fruits and growers can sell their produce readil and profitably.

In the case of the *Hatti bahar*, however, no proper treatment o trees is possible owing to the preceding wet months. The tree cannot be forced to rest from vegetative growth, as stoppage o water is impossible because of rains. This *bahar* is, therefor not treated for ordinarily, except when for some reason o other, the first two *bahars* are missed or are unsuccessfu When this *bahar* is obtained, it is poor and not remunerative.

Selection of *bahar*

The question as to which *bahar* to treat the trees for, depend upon several factors for its answer. Treating trees for an *bahar* presupposes the availability of labou irrigation water and market for the crop a

particular seasons. Pests and diseases also determine the choice of *bahar* in many cases. In the Poona, Ahmednagar and Nasik districts, orange trees are more commonly treated for the *Ambe bahar*, because in these tracts, orchards depend upon canal water which is assured even during the hot months when fruits set and develop. Labour is also available during the months of December to January when the *kharif* or rainy season crops are practically harvested. The presence of large cities like Bombay, Poona, Nasik and Ahmednagar assures a market for the fruits during the Christmas season. These facilities help the growers to successfully raise the *Ambe bahar* crop. Of course, this crop is damaged to a great extent by the fruit puncturing moth during the rains, but the other advantageous factors counterbalance the loss due to the moth.

In the Khandesh districts (as well as in the Central Provinces) the common *bahar* for which orange trees are treated is the *Mrig bahar* (so called because flowers appear when the sun passes through the *Mrig*, deer—constellation). The orchard commonly depends upon well irrigation, and the wells go dry in the hot weather. If trees are treated for the *Ambe bahar* in these tracts, they have to be watered properly during the hot months, which is not possible and the crop might fail. Resting of trees for the *Mrig bahar* means withholding of irrigation to the plantation during the months of April to June, and this synchronises with the scarcity of well water Natural difficulties are thus overcome. The damage caused by pests during the monsoon months is also minimised, and the crop comes to harvest during the months of March-May when there is a good demand for the fruits. This *bahar* is therefore considered very advantageous in tracts which have to depend upon well irrigation and distant markets. Of course, there is considerable difficulty to get labour in May and June, when the preparation for the monsoon crops is in full swing.

As noted above, the *Hatti bahar* is not of much consequence and can be taken anywhere, if the first two *bahars* fail and if the weather permits. This *bahar* is successful only if there happens to be a long break in monsoon in the month of September, when the trees can be rested.

It is always highly desirable as already stated to treat a plantation for only one *bahar* and to stick to that *bahar* year

after year. By doing so, the trees get accustomed to definit seasonal treatments and they respond to them very well Regularity is established in the cyclic orde of operations of cultivation, and they becom almost automatic.

Changing the *bahars*

Changing treatments from *Ambe bahar* i one year to *Mrig bahar* in the other disturbs regular arrangement and causes economic loss. Trees treated for *Ambe bahar* in Decem ber of one year cannot be treated for *Mrig bahar* the followin June, unless the *Ambe bahar* fruits are sacrificed. Resting th trees more than once a year is to be very harsh on them, an the trees may suffer in consequence. Similar is the case wit trees treated for *Mrig bahar* of any year. If, therefore, it i desired to adopt *Mrig bahar* as a regular routine practice fo future years in a plantation which is accustomed to *Ambe bahar* i the previous years, then it is desirable to drop all treatment fo *Ambe bahar* in the December of one year, when treatment is ordi narily due, and instead to treat the trees for *Mrig bahar* in the following hot weather. This naturally means the loss of si months more between two *bahars*, which thus come at an inter val of eighteen months. But this happens only once in the plantation and the loss caused thereby is not much. Changing *bahars* frequently is not desirable in the best interests of the trees, as well as of the proper income from orchards.

The citrus trees are the chief group of fruit trees which are artificially treated for the crop in this Presidency. Horticultura knowledge of exposing roots of trees and resting them is brought into practical play in this group more than in others. The cul tivation of citrus trees is, therefore, considered to be of a dis tinctive character. It may be due to the equitable climate of the Deccan that the trees respond well to these treatments. In Sind and the Punjab as also in South India, the citrus trees do not seem to require any root treatment for flowering. The severe cold during the winter in North India perhaps forces the trees to rest during that period. As soon as spring dawns, the trees become active and rush into flush with flower and frui buds. Irrigation is stopped during winter, but that is don because it is no use watering trees while they are resting, an not in order to force the trees to rest artificially from vegetativ growth. The soil in citrus-growing regions in North India i alluvial loam and very deep. Withholding water alone is enoug

any measure is needed at all to rest the trees. Even in the eccan, it is observed that trees do not require their roots to be xposed for resting in lighter shallow soils. Withholding of water r a period depending upon the nature of soil is enough to force lossoms under these conditions.

Root pruning of citrus trees is definitely a weakening process. Vhile its value in regulation of crops cannot be denied under the Vestern India conditions, it has to be admitted that repeated nnual pruning of roots may reduce the longevity of trees by rogressively impairing their growth. It has been observed that hen roots are pruned, a large net work of fibrous roots is formed om the cut ends during the first year of the operation. This ower of root regeneration, however, gradually gets reduced by nnual root pruning, resulting in a corresponding reduction in rowth and production. In heavy soils, root pruning may roduce some benefit by providing better soil aeration, but such result is not likely in open soils. The deleterious effects of the ractice of annual root exposure and root prunings are being ealised in several orchards, particularly in southern and northern ndia. Even in the Bombay Presidency, it is advisable to find ut how the effects of root pruning can be brought about by ther and less severe orchard operations. At any rate, it appears ecessary to suggest that root pruning may be resorted to in-equently once in two or three years in normal citrus groves, nd annually only in the case of very vigorously growing and hy bearing trees, perhaps in heavy soils. In the latter case, it ill also be better, if the soil is exposed farther away from the egion exposed in the previous year, so that the roots are not urt in the same place year after year.

A method of root exposure followed by heavy manuring in rder to produce limes in the summer season is practised in aly. It is said that this practice does no harm to the tree, rovided it is carefully cultivated.

While treating orange trees for flowering, the period of opping irrigation depends chiefly on the nature of the soil. If ie soil is heavy and sticky, the trees do not show any sign of ithering even if water is stopped for three or four months. oot exposure has also to be very severe in such heavy soils. lighter soils, stoppage of water completely for about a month found enough.

Kagdi limes

The cultivation of *kagdi* lime plants is receiving a great d of attention in the Bombay Presidency in recent years. T fruit is considered to be of economic imp tance as it holds out a future for the lime ju or squash industry, apart from the use of fruits in their fr condition.

Propagation by seed was the rule in the case of this fr until lately. But it is now observed that if lime is raised budding upon *jamburi* rootstock, the trees fruit earlier a the fruits become larger in size. The chief difficulty in budd *kagdi* lime is that many of its buds are accompanied by tho and it is not easy to take out a thorny bud for insertion, with prevalent method of budding. However, with some practi the lower buds on a shoot can be carefully taken out and serted with fair success. The method followed and other con tions of budding are exactly the same as for oranges.

In the West Indies, budding of limes on sour orange ro stock is widely practised. Sour orange is reported to provid deep tap root for the limes, which when grown from seedlin develops only a system of surface roots.

Lime trees on sweet orange or rough lemon (*jamburi*) ha shown in California to make better growth than those on so orange and trifoliate rootstocks. In Kodur, budded lin have yielded earlier and better harvests, trees on *Gajanim* having performed the best.

In Dominica (109) sour oranges were resistant to dise and hurricane when used as rootstock to limes. The yie also have been much greater than on seedling trees.

Kagdi lime plants are planted 18 to 20 feet apart in mediu black soils in the Bombay Presidency. In alluvial and mo fertile soils, it is desirable to give them a larger space lest trees get overcrowded in a short time. These trees more spreading in habit than several other citrus trees. plantation on the bank of the river Tungabhadra in the Kap valley tract of the Dharwar district, was seen to thrive w a spacing of twenty feet each way and to present alm an overcrowded appearance. Trees in the Khandesh tr are also seen to spread out and occupy twenty feet sp in a few years. In rich soils even 25 ft. spacing is, however, fou inadequate in South India.

This fruit is very popular owing to its high medicinal alue. It has become almost a necessity for the table in the aily life of Indians. The tree adapts itself to many kinds of oil and climate. It is perhaps more adapted to tropical conditions than the *Mosambi* or *Santra* orange trees. It thrives well in irsi (Kanara) with an annual rainfall of more than 99″. It also rows well in the drier parts of the Deccan, as, for example, the Khandesh districts, with an annual rainfall of only 30″. It seems o be more susceptible to frost conditions than other citrus trees, nd that is one of the chief reasons for its limited cultivation in the Northern provinces of India.

In regard to its requirements of manures, irrigation and ther items of cultivation, lime trees are akin to orange trees in nany respects. They come to bearing a little earlier than the range trees do, although a regular crop can be had from the ourth year onwards in Bombay Presidency.

Under natural conditions, the trees are seen to bear owers all the year round, each flush bringing forth blossom. The period from flowering to harvest is about six months. This act makes a difference in the economics of lime and orange ultivation in this country.

The chief harvest of limes falls in the monsoon when the emand for the fruits is very dull. Fruits have, therefore, to e sold cheap and the growers consequently suffer. During the ot weather, when fruits are in demand, the crop is scanty and rices rise. If, therefore, the trees could be forced to flower in the nonths of September to November, the fruit will be harvested in he months of March to May when the market for it is active. ut this is difficult to adjust, owing to the rains in and preceding the September month. The natural *bahars*, namely, the *mbe* and the *Mrig*, come to harvest in the rainy and winter seasons nd the demand for the fruit in both these seasons is very low. n years when there is a break of rains during August and September, the trees flower soon after and fruits are harvested in March to May. But this rarely happens. Attempt is, therefore, eing made to preserve the juice of the rainy season fruits in bottles for use in the hot weather, as is explained elsewhere.

At present, although the Presidency of Bombay has an area of bout 2,600 acres under *kagdi* limes mostly spread over parts of he Deccan and Gujerat districts, the cultivation of this fruit is

not extending as much as it should have done. But the situati may improve when the lime juice industry makes a headway

A summary of the breeding work so far carried out in citr has been published by the United States Department of Agricu

Citrus hybridization

ture (309). The difficulties in the way breeding citrus fruits owing to the long tin required to produce new varieties and to the phenomenon polyembryony are clearly understood.

The controlled pollination technique in citrus presents r special difficulties, mainly because of the relatively large size the flowers and the fact that the pollen can be stored for over tw months. With the multiplicity of forms of citrus existing in Ind and diversity of regional requirements, there is no doubt th ample scope exists for breeding new varieties of citrus wi desirable combinations of fruit and tree characters now found i different citrus varieties. Such work is overdue and has to b undertaken on a nation-wide scale.

Mosambi and *Santra* fruits are ready for harvest generally i about ten months from flowering. Fruits develop a dull or yellow

Harvesting of fruits

ish orange colour in the Bombay Presidenc In the Ahmednagar and Khandesh district where the climate is drier and colder during winter, an hotter during summer, the fruits develop a fine golden orang hue when ready for the market. Harvesting is generall done according to market conditions. The orange fruits ca be retained on the trees in the Presidency for over a couple months and sometimes for even three months after maturit Fruits of the older *bahar* are always valued higher in the ma ket for their sweetness and finer quality as compared with thos of the current season.

Some care is necessary at the time of picking the fruits and al in handling them at the time of packing and transportatio Clippers are used in most citrus growing countries to harvest th fruits, and pulling them by hand is prohibited. Fruits are the placed, not dropped, in small low trays or packing bags, and lat transferred to suitable containers. In some countries, the frui are allowed to remain in shallow trays for several days t sweat off excess moisture. Three days' storage in packing hous is recommended for Palestine oranges during which time th fruit shrinks, loses its surplus moisture, and its skin becomes le

nsitive. It is also possible to inspect satisfactorily fruits .at have been previously damaged. If the fruits are to be ored for any length of time, dipping them in copper sulphate lution of 0·2 percent strength for one or two minutes is done. acking of the fruits is done only after the fruits are thoroughly ried.

Colour does not usually afford a good indication of the matuty of citrus fruits. In cooler regions, citrus fruits have ample olour long before they attain the desired quality, while in warmer acts the fruits become sweet some time prior to their attaing the ripe colour. Enclosing fruits in bags against pest tack, as is done in parts of South India, also hastens colouring the fruits without simultaneously hastening the maturity. n the case of sweet oranges, the juice should be about 30% of the otal weight of the fruit at the time of harvest. In some foreign ountries, the sugar-acid ratio of the ripe fruit of different varies has been determined and laws have been enacted to prevent e export of fruits that do not conform to the minimum ratio andard. In Palestine, the ratio between the citric acid and ugar contents is required to be in the proportion of 1:8 in sweet ranges at the optimum harvesting period. Citrus fruits are lso artificially cured (or coloured) in some countries by the pplication of ethylene or acetylene gas. In Florida and elsehere in the United States of America too, the total solids to acid atio is commonly used as an indicator for ripeness, but it is ealised that for oranges no one standard minimum such as, for nstance—the 8: 5: 1 ratio is suitable for fruits from all regions. he titratable acidity determinations have recently been dopted in New South Wales, but this kind of test did not prove tisfactory in Jamaica. In South India for the fruits from edling trees no satisfactory indication could be devised on the asis of sugar-acid ratio.

It is considered best to start picking on a fine day early in e morning, but after the damp or dew has all evaporated and e fruits are dry.

Excessive rainfall during the harvesting period leads to a ongestion of the epithelial cells, a watery state of fruits, and roting. Oranges, therefore, should not be picked during wet eather. It is also recommended in Palestine that the best ethod is to pick orange fruits from lower branches first to

prevent rotting, then of the higher branches to reduce winc falls, and lastly of the middle part of the tree.

It will be shown hereafter that the time of picking citrus frui is important for successful storage. At present no authenti data on the best period of picking of Indian oranges are availabl As there is a usual tendency on the part of the growers or orchar contractors to retain the fruits on the trees for a very long period i times of glut, investigations to ascertain the effect of such delaye picking on the storage life and on the subsequent crops, requir to be undertaken. Such investigations will have also to tak note of the effect of the orchard cultural treatments on the tim of maturity.

The yield from sweet orange trees varies greatly accordin to variety and locality. In California, a report for 1936 show that the most profitable orchard had an yiel of 260 packed boxes per acre, with a box valu of $ 2·10 while the least profitable orchard had an yield of onl 103 packed boxes with a value of $ 1·68 per box. In some part of the Madras Presidency, an annual income of over Rs. 1,000/ per acre from citrus growing has been realised (182). Thi shows that citrus fruits play a very important role in the rura economics of this country at the present moment.

Yield

The results of the observations made in California indicat a depressing effect of a large crop in the amount of fruit in th succeeding crop, which effect increases with the length of tim the crop remains on the tree. No consistent relationship between the amount of crop and fruit size is observed.

Grading oranges with the help of a cheap grading machine i an easy method, and has been attempted by some persons i this country. A simple device for grading sweet oranges has been under test at Kodu (Madras). The machine consists of an inclined plank restin on stands and having a number of holes of different sizes made i it to permit the fruits to drop down through them as they ar made to gently roll over. The smaller holes are made o the top of the plank and larger ones at the lower ends Gunny bags are attached to collect the fruits that dro through these holes, the number of bags depending upo the number of grades (sizes) intended to be adopted. Th bags are attached to the plank in a manner to permit a gentl

Grading

olling of the fruits instead of sudden drop through the hole. Vith fruits like *Santras*, grading is possible only by hand, as no uitable and cheap grading machine has been devised yet for uch fruits. Recently the Madras Agricultural Department ias devised and popularised a more efficient machine for grading weet oranges and another for acid limes, and both these have ecome very popular. The elaborate mechanical grading nachines used in foreign countries cannot hope to engage the erious attention of the citrus growers in India for some years o come until co-operative organizations are developed on an xtensive scale, and are able to handle very large quantities of ruits.

Grading of fruits as it is practised in India, and discussed ierein, relates actually to the sizing of fruits only. Real grading, iowever, should include grouping of fruits according to colour ind maturity stages. Both these points are taken into consideraion to some extent by the retailers who resort to hand grading, ut the cheap grading machines referred to above do not lend hemselves for sorting out fruits of different colours and stages of naturity nor have any methods been evolved in this country vith such purposes in view.

Packing of oranges

Santra and *Mosambi* oranges in the Bombay Presidency are enerally packed in cylindrical bamboo baskets with little packing material for marketing purposes. The basket is closed by tying the bamboo lid on the op with a coir or twine piece. It is labelled and transported ither by railway or by motor buses. The baskets ordinarily hold ibout three dozen fruits, and are sold in the market after opening ieir lids either in basket lots or in retail. The retailer displays ie fruits well on the stall or his push cart as the case may be, nd it is he who practically grades the fruits.

A few planters in North and South India have attempted acking their citrus fruits in wooden cases of the types adopted i foreign countries. The fruits are carefully picked, and their tems pruned off to a button. They are rubbed gently but well vith a flannel piece to remove dirt sticking to the rinds, and ien graded and wrapped in thin tissue paper, which is twisted ff to a pig-tail. There is no standard system of packing, alhough the Californian standard package appears to be more opular than others.

No organization to sell citrus fruit in the Bombay Presiden is yet formed on the lines of the Citrus Exchange of Flori and California. Fruit is also not treated f its colour and appearance with ethylene gas in those countries. Grading and improv methods of packing are being taken up by growers nowaday and instead of packing them in fragile bamboo baskets, loose gunny bags as heretofore, they are being pack in wooden boxes. It is, however, observed that during t season, *Santra* fruits are filled loosely in railway wagons a sent from Nagpur in the Central Provinces to Bombay, distance of about 500 miles. It is true that the rind of orang and lemons is tough, and can stand long railway journe without much damage to the fruits but pressure of the upp layers of the fruits and rough handling in transit do affe them considerably and they are seen to fetch low prices in t market.

Marketing organization

In this country, the standing seasonal crop of citrus, as other fruit crops, is usually sold to the contractors or middleme who in turn consign the fruits to commissio agents in the various cities and towns. Som times the crops are sold to the middlemen two or three yea ahead, in which case the orchards are either maintained by th grower or by the middlemen, according to the stipulations mad in the agreement of sale.

Marketing of fruits

The commission agents may also undertake the purchase the orchards on contract in addition to their own normal dutie The fruits on arrival at the warehouses or godowns of the com mission agents are sold to the retailers or the public throug private treaty or public auction. The latter method of sale is on resorted to in times of glut, or when the fruits are in an advanc state of decay. The retailers dispose of their fruits in shops through hawkers. Some of the commission agents also mai tain connections with a large number of hawkers, who colle the fruits for the day's sale from the commission agent's godov and credit the sale proceeds at the end of the day direct to t commission agents. This system is in vogue throughout t land with slight local variations. The large number of links the chain and the manifold abuses that have crept in, in son parts in regard to the methods of sale and also in the matter

ayment of the full value realised for the produce to the consignees, have resulted in rendering the fruit growing industry ı this country very uneconomic on one hand, and raising the alue of the fruit available to the consumers to an abnormal vel without guaranteeing a reasonable share of the high prices ɔ the growers, on the other.

In March, 1949, rules for grading of citrus fruits were drafted nd included in section 3 of the Agricultural Produce (Grading nd Marking) Act, 1937 (I of 1937).

Cold storage experiments conducted on Nagpur *Santra* fruits t the Ganeshkhind Fruit Experiment Station, Kirkee have shown that these fruits can be well preserved at low temperatures of about 40°F for three months. Results of investigations carried out n other countries have been summarised by Wardlaw in a series f articles, and these indicate that a considerable temperature ange is cited in different countries for the cold storage of citrus ruits. The time of picking oranges in relation to maturity is ndicated to be of extreme importance (10). In Trinidad, 40°F s advised for most sweet orange varieties. Fawcett (81) recommends 38° to 40°F for Californian oranges, but advises a ange of 32°F to 40°F, to combat the stem-end rot. For Rhodesian oranges, Bates (18) cites 40°F as the most suitable torage temperature. That the keeping quality in storage is onsiderably affected by cultural treatment such as girdling and pplication of nitrogenous fertilisers at certain periods is wellknown and has been proved by the Arizona experiments (9).

ɔold storage
xperiments

There is very little information available at present on the as storage of citrus fruits. On the basis of his work on as storage of Valencia oranges, Samisch (225) states that "It would seem that gas storage of oranges would be of minor praccal importance", in view of the fact that the difference in hange of composition of the edible portion of Valencia oranges etween different extremes of gaseous environments was very mall. The CO_2 treatment produced also a specific injury to the ind, while storage of oranges at low temperatures did not cause ny harmful effects and in fact was effective in the control of lecay.

Oranges and limes are preserved in foreign countries in arge quantities and in a variety of ways. In India, however,

the only kinds of products that were prepared out of th fruits till about a decade ago were pickles, syrups and squash

Preservation of citrus fruits

Preserving them as marmalades, candi peels, juices, citric acid, etc., was alm unknown in this country till recently. Late owing to the efforts made by the Agricultural Departments over the country and more especially due to the transient dema during World War II, the public are being awakened to t possibilities of developing a highly lucrative industry in pr serving these fruits. A beginning in the manufacture of some the latter products has been made in different parts of the countr The marmalades of oranges and other citrus fruits, lime squa and lime cordial, lime pickles, etc., made by these firms a becoming gradually popular with the masses. The mark for these products is yet to be developed on a larger scale India. The existing demand has been met in the past by pr ducts imported from abroad at a high cost. Such imports ha not ceased even with the protection given by the Governmen A great deal of headway remains to be made in the matter economy in the cost of production and towards improveme and standardisation of quality.

Of all the citrus fruit products, orange squash, especially fro sweet oranges, is perhaps the most appealing, though rather e pensive. The method of preparing this is explained below :—

Fully ripe oranges after thorough washing are either cut int halves (in Maltas) or peeled by hand (in *Nagpur Santra*). Th

Orange squash

juice is extracted with a juice extractor, revolving cone made of glass, monel meta or such non-corrodible metal in the case of sweet orange or meat-mincer type squeezer in the case of loose skinned fruit and then strained through a coarse muslin cloth or a pulpir machine. For medium sugar content squash, the ingredien are added in the following proportions: juice: sugar: citric acid= 10 lb.: 7 lb.: 4 oz. For high sugar content squash the propo tions are: juice: sugar: citric acid=10 lb: 15½ lb.: 7 oz. Edib colour (Niagra concentrated orange powder or Edicol A. G at the rate of 1·5 gms. per 100 lb. of the squash is added by di solving the same in a little of water and mixing it thoroughly wit the squash. The preservation of the squash for long storage effected by the addition of potassium metabisulphite at the ra

f one ounce for 100 lb. of the finished product and packing in terilized bottles which should be sealed air-tight.

The lime and lemon squashes are popular beverages and elatively cheaper than orange squash. They are prepared as ollows: Fully ripe fruit after washing is cut into halves and the uice extracted with an extractor. The straining of the juice is done through a pulping machine or a coarse muslin cloth and the proportions of the ingredients for medium sugar content squash are: uice: sugar: water=4: 5: 3 and for high sugar content squash: uice: sugar: water=1: 2: $\frac{3}{16}$. The ingredients are mixed horoughly and the prepared squash is preserved by the addiion of one ounce of potassium metabisulphite per 100 lb. of the repared squash and bottling in air-tight sterilized bottles.

ime or emon squash

A clarified fruit juice, in which all suspensions are elininated, sweetened with appropriate quantity of sugar is known as cordial. The juice of limes or lemons is strained through a thick cloth and tored in deep non-corrodible vessels with potassium metabiulphite added at the rate of an ounce per 100 lb. of the juice. For quicker clarification, special reagents are used. The clean uice devoid of all suspended matter which settles at the bottom after about a month's storage, is syphoned and mixed in the proportions—juice: sugar: water=4: 5: 3. The additional quantity of potassium metabisulphite (proportional to the weight of sugar and water) is added and packed in sterilized bottles and sealed air-tight.

ime juice cordial

To prepare lemon barley water, a thick paste of the barley vater is first made out by thoroughly mixing 3 oz. of barley flour (Robinson patent barley flour) in one gallon of hot water. The paste is then cooled and sugar added to raise the Brix to 50°, vhen it is strained through thick cloth. This is then mixed with half the quantity of lime or lemon juice, strained through a oarse muslin cloth, and potassium metabisulphite added at the ate of 1 oz. per 100 lb. of the prepared product. It is placed n sterilized bottles and sealed air tight.

emon barley vater

An addition of 10% mango pulp to citrus squashes as a source of colour instead of dyes is reported to have proved very satisfactory at Lyallpur. While the mango flavour becomes imper-

ceptible after about 4 months, the colour is fully retained. Ti mango pulp was prepared during the previous summer ar stored either with 0·1% potassium metabisulphite or after pa teurization.

It is suggested that the rind of the fruits which are crushe for the juice may be well utilised by salting in preparation

Use of rind

pickles as well as a flavouring agent. Th by-product is very bulky and can be sol cheaply and with good profit (34).

The halved citrus peels (Malta, grapefruit and lemon) ca be utilized to produce a welcome addition to the edible by

Candying of citrus peels

products from citrus fruits. These peels ar cleaned of their rag by means of special spoor shaped knives and then washed thoroughly Curing of these peels is done by soaking them in 2% commo salt solution, adding an amount of common salt so as to increas the strength of brine by 2% after every 24 hours till a fina concentration of 8% common salt is reached. At this stage th old 8% brine is replaced by a fresh one to which potassiun metabisulphite is added as required and the whole stuff store in well closed air-tight vessels for at least six weeks. Afte this period the salt-cured fruit is boiled till it becomes soft anc most of the salt absorbed by the peels is removed. This is ther washed in fresh running water and drained over a large sieve The drained and prepared peels are put in boiling 30° Brix syru (containing 0·1% citric acid to effect partial inversion of sugar and heated to boiling. The peels are covered with a lid so tha they are left completely submerged in the syrup. Next day th syrup is drained off and enough sugar added to bring the suga concentration to 35° Brix. The syrup is heated to boiling anc poured on the peels for absorption of sugar during the nex 24 hours. The sugar concentration of the condensing syrup i increased by 5° Brix. After this it is increased on alternate day in similar manner till the syrup strength records 75° Brix when the peels are kept submerged in the syrup for 3-4 days after which they are drained and dried preferably in the shade.

Marmalades of good quality can be prepared from a numbe

Citrus marmalade

of citrus fruits. A method of preparing th product is described below:—

Only the upper yellow portion of the skin of the thoroughl

Ascorbic acid content of citrus fruits

Values expressed as milligrams per 100 grammes

Food	Description	Quantity of ascorbic acid		Year reported	Investigator
		Dye method	Iodine method		
Orange		60	71	1933	Bessey and King (26)
	Unripe	45	—	—	
	Ripe	50	—	1935	Giroud, Ratsimamanga and Lebloud (98)
	Ripe, weight 58·85 g	51·5-54·3	—	1935	Ranganathan (203)
	C. aurantium pulp	18	24	1935	Ghosh & Guha (97,
	Mandarin (*C. nobilis* delicose)	31·5	—	1935	Ahmed (1)
Orange-stored	16 hrs. wt. of average 58·85 g	50·7	—	1935	Ranganathan (203)
	24 ,, 1·25 g waterloss	61·6	—		
	48 ,, 2·29 g ,,	60·1	—		
	72 ,, 3·18 g ,,	57·2	—		
	96 ,, 3·88 g ,,	53·0	—		
	144 ,, 5·26 g ,,	60·8	—		
	216 ,, 6·91 g ,,	54·6	—		
	264 ,, 8·43 g ,,	56·4	—		
	312 ,, 10·04 g ,,	61·6	—		
	384 ,, 10·98 g ,,	47·48	—		
Lemon	*Citrus limonia*	42-65	—	1934	Bacharach, Cook and Smith (12)
Lemon albedo	—	46	51		
Lemon flavedo	—	210	220		
Lemon peel	—	100	—		
Grape-fruit (*Citrus grandis*)	—	53	53	1933	Bessey and King (26)

Composition and vitamin content of orange and lemon juice worked out by Mottram and Graham (178)

	Grammes per 100 gms.				mg. per 100 grammes								Acid base balance per 100 gms.	Vitamins I.u. per 100 grammes		
	Protein.	Available carbo-hydrate	Un-available carbo-hydrate	Calories per 100 gms.	Na	K	Ca	Mg.	Fe.	Cu.	P.	Cl		A	B_1	C
Orange Juice	0·6	9·4	0·0	41	1·7	179	11·5	11·5	0·30	0·05	21·7	1·2	45	300	—	400
Lemon Juice	0·3	1·6	0·0	8	1·5	142	8·4	6·6	0·14	0·13	10·3	2·6	38	—	—	520

·ashed fruit is removed with a sharp knife or a peeling knife except *Santra* which can be peeled by hand), leaving as much of ne white portion of the peel as possible. The peeled fruit is then ut into thin slices to which enough water is added so as to cover ne skins. It is then boiled for half an hour to extract pectin and ne extract strained through thick cloth or jelly bags. The ectin test is performed with a jelmeter or with 95% alcohol and he degree of richness of the pectin determined. A calculated mount of sugar is added and the mass heated to about 218°F, hen fine peel shreds are added and the heating continued) 222°F, which is the closest temperature to the jellying point. he marmalade is poured hot into clean sterilized screw cap jars, cum is removed and the mouths of the jars covered till ompletely cooled and set. A thin layer of paraffin wax is pplied at the surface to prevent the product from the weeping ffect and spoilage.

'ood value

Pectin forms an important constituent of citrus fruits and with he fruit acid is responsible for the set of jelly and marmalade, as has already been shown above. It can also be extracted in the form of powder. Citrus ruits as a group are reputed for their healthful dietetic properies. They are generally a rich source of calcium. The calcium ontents of oranges and orange juice have been shown to be ffected by the variety, soil and fertiliser. With the membrane urrounding the section of the orange the calcium content is aid to be almost twice that with the membrane removed.)ranges are also a fair source of Vitamin A, and an excellent ource of vitamin C. Extensive tests in Arizona showed that fruits om trees so managed as to give a low nitrogen content at arvest consistently contained 20-25% more ascorbic acid than iose from trees with higher nitrogen level. Grapefruit juice ave a negative correlation co-efficient between nitrogen and scorbic acid. Also see pages 203, 204 and 206.

)iseases and pests

Citrus trees in the Bombay Presidency suffer from several oubles both pests and diseases of organic physiological nature. The commonest of these are the dieback, gummosis, canker, root rot, cracking of uits, the fruit sucking moth, stem borers, scale insects, aphis nd the lemon caterpillar. A type of chlorosis and mottle leaf re also seen. The root rot of citrus trees, the cause of which is

Read and his co-workers (205) analyse the citrus fruits in Shanghai as follows:

Name	Edible portion.	Water	Protein	Fat	Carbohydrate	Crude Fibre	Calories 100 gms.	Ash	Ca	P	Fe	K
Orange (*Citrus nobilis*) Lour var. ..	80	86·76	0·58	0·35	11·55	0·40	53	0·36	0·020	0·008	0·0020	0·142
Lemon (*Citrus Medica* L.) var. Limonum Hoak	65	89·37	0·82	0·89	7·84	0·65	44	0·43	0·033	0·024	0·0006	0·193
Pummelo (*Cirus decumana* L.)	61	84·82	0·74	0·56	12·20	0·82	58	0·86	0·041	0·043	0·0009	0·332

Average composition of edible flesh of fruits by chace et al., quoted by Winton (348) is as below:

	Solids total %	Solids Insol. %	Protein %	Acid % (citric)	Invert Sugar %	Sucrose %	Ash Total %	Ash Alk.
Orange ..	11·38	2·70	0·72	2·65	4·45	5·29	0·57	..

TRENCHING AS A REMEDY AGAINST DIE-BACK IN AN AFFECTED *MOSAMBI* ORCHARD AT KOLHAR.

Facing page 207.

not definitely known, has been spreading fast lately and devastating several flourishing orchards.

Citrus die-back

Different forms of citrus die-back prevalent in peninsular India have been described. It appears that *Mosambi*, *Santra* and grapefruit are the only three types of citrus which are mostly affected. This disease has assumed very great importance in India as a great deal of damage is done to the plantations. The disease has taken a very large toll of citrus orchards especially when they are raised without proper selection of the soil. Defects in cultural treatments are also found to predispose the trees to this trouble. In fact, several factors acting singly or jointly are found to induce this disease in most of the groves.

The die-back trouble seems to have been prevalent in the Bombay Presidency for a long time. Its seriousness was first recognised by the Bombay Agricultural Department in about the year 1912. Certain preliminary trials in treatment were made about the year 1921. A study of the trouble combined with a survey of the conditions under which it occurs, and regular experiments to reproduce the trouble under controlled conditions were undertaken during 1924-25. From observations recorded by the Department of Agriculture, it is evident that the soil and climatic conditions are closely associated with this disease. The nature of this disease is physiological since no organism is found associated with it. Remedial measures taken with a view to correcting physiological disturbances have been partially successful.

Symptoms of die-back have peculiar characteristics of their own. Whole plantations, individual trees or trees in patches may be affected. The disease usually makes its appearance after the first or second bearing. Younger trees may also be affected under extreme conditions. The first symptoms appear when the terminal leaves and shoots turn yellow. This yellowing is different from simple mottling or the yellowing of ripe leaves. The symptoms appear all at once in the new shoots of a fresh flush. The trees may apparently be in perfect health, before the flush, but all of a sudden they begin to produce pale tender leaves which do not mature at all. They fail to develop the normal green colour. After a time, they attain considerable turgidity and remain stunted and pale. Often, variegated leaves

are also observed. The variegation is caused by regular stripes of green and yellow colour alternating one another. The green colour is mostly seen alongside the main veins indicating a collection of chlorophyll matter on either side of such veins while the yellow stripes are deficient in chlorophyll. All the new sprouts, however, may not exhibit this symptom. The new sprouts arising on one or more main branches only may show the symptom in the beginning, but subsequently, more branches will be attacked, while those that were already attacked get worse. Again, when the symptoms appear, they do so not on one or two or a few individual fresh sprouts in a sporadic manner, but on all the new sprouts on a main branch. The unit of attack is, therefore, a main branch of a tree and not an individual sprout or two. From the time the first attack is seen, it may take from one to two years before the whole tree is seen to suffer. This is why in the earlier stages of the trouble, it is seen on some parts of trees only, while the others remain apparently healthy. The further symptoms are the death of yellow shoots and leaves extending gradually to the lower parts with a dimunition in the bearing capacity of the affected tree. Fresh growth on an affected branch is very sparing and new sprouts never develop normally either in colour or in vigour. The region on the trees in which new sprouts appear is pushed downwards as it were, and dormant buds on the thicker stems just below the dead parts come into activity. In a tree of advanced infection, it is only the basal stems of the main branches that survive with a few undeveloped yellow multiple sprouts on them. At this stage, which is reached in about four years from the time the first attack is seen, the tree cannot bear even a single fruit and it dies soon after. The formation of gum-pockets and dark excrescences as described by Floyd (86) in the United States of America is not seen under the conditions obtaining in the Bombay Presidency. While these are the prominently visible symptoms of die-back, a detailed examination reveals that every part of the affected tree displays a characteristically deteriorated condition of health. When die-back appears on the branches, the roots are seen to shrivel and are reduced in number. The roots may disappear under dry conditions and may rot under conditions of stagnation of water. The internal structure of the branches as well as of the roots undergoes very great changes and everywhere disintegra-

ion and rotting are seen. With the symptoms progressing apidly, the whole tree dies in about four years.

From the investigations carried out so far, by the Bombay epartment of Agriculture, it would seem that certain soils and oil conditions predispose the plants to die-back, as for example,

1. Soils containing an excess of lime;
2. Soils deficient in plant food;
3. Soils deficient in aeration;
4. Soils having a hard subsoil;
5. Soils in a water-logged condition.

Hence the precaution to be taken against this disease appears to e such measures as will eliminate or minimise the defective conlitions. Similarly an orchard suffering from die-back can be estored to health by adopting measures that will correct these re-disposing factors.

Bates (17) summarising the results of the investigations on the lie-back of citrus in South Africa states that, (i) damp and cloudy veather with heavy rain at intervals, (ii) growing dense cover rop of sann hemp in close proximity within a radius of six feet rom the tree, and in many cases higher than the young citrus rees, and (iii) too many young lateral shoots allowed to develop etween the union and head, contribute to the incidence of this lisease.

Pot experiments have shown that the application of leaf nould is an effective treatment for *Mosambi* orange trees when hey suffer from die-back in limy soils. In orchards where dieack appeared as a result of water-logging caused by overrigation, the trees had improved when the water was rained away by a deep open trench. Subsequent application of a good dose of manure aided their recovery. Under dry onditions of soil, loosening the soil has resulted in the improved ealth of the trees accompanied by good bearing. A carefully onducted experiment at the Ganeshkind Botanical Gardens now the Ganeshkind Fruit Experimental Station), Kirkee, on bout 110 five-year-old trees, has shown that the application of nanures and trenching have all curative as well as preventive alues, irrespective of the degree to which the trees have responded to them. The application of sulphate of ammonia at ntervals of three months induced the best growth of the trees,

and helped diseased trees to recover to the greatest extent. Opening trenches three feet deep and two feet wide in the centr of the rows of trees planted 20′ apart also induced the recovery of the trees to a great extent, and stimulated profuse growth or the trees. Leaf mould at the rate of fifty pounds per tree, came next in order of merit in improving the affected trees. Addition of lucerne-field soil to the trees did not prove to be effective.

It may be noted here that these methods have been readily taken up by growers with considerable advantage in improving affected orchards. Sahasrabuddhe (223) records a very interesting experiment in curing die-back of oranges in black soil in the Ahmednagar district. The treatment consisted of opening trenches to improve the aeration of the soil. He treated an orchard of about 400 trees of *Santra* suffering severely from die-back. Trenches were opened out in between the rows wherein water and manure were given to the trees. The dose of manure given per tree was as follows:—

Niciphos ..	.. 1½ lb.,
Sulphate of ammonia	.. 1½ lb.,
F. Y. M. ..	.. 2 baskets.

The trenches were then closed and irrigation given in between the trees in broad furrows where a cultivator was worked after each irrigation as soon as the soil came into condition. The trees bore a full crop in this grove. At Kolhar in the same district and under similar soil conditions a Santra orchard suffered from over-irrigation verging on stagnation with canal water, resulting in serious die-back. The plantation improved when two to three feet deep trenches were opened out to drain away the excess of water.

Gummosis disease

Gummosis is another serious disease of citrus in th Bombay Presidency, and is known to result in a very con siderable damage in the absence of a suitabl treatment. The cause of this disease is fungus parasite (*Phytophthora palmivora*) which lives in the soi Under favourable conditions of soil moisture and temperature the fungus produces spores each of which produces a swarm c spores which swim about for sometime—and then give rise t fungus threads (hyphæ). These threads enter the plant at th bud-union but cannot penetrate the *jamburi* rootstock since

s resistant to the disease. If *Mosambi* trees are therefore bud-ded high enough on *jamburi*, there is practically no danger of the lisease even under conditions of fairly excessive irrigation or rain. After the fungus has entered the bud-union, it invades the bark and the invaded region extends over considerable distances up-wards, but over smaller distances sideways. The bark is killed through to the wood, and a watery substance is formed underneath it. As the watery substance accumulates in large quantity, the pressure increases ultimately rupturing the bark longitudinally. Large quantities of gum are exuded rom the vertical cracks. If the bark in the invaded portion s scraped with a knife, the inner surface shows a brown dis-colouration, which gradually fades at the margins of the in-vaded zones into the normal colour of the sound tissue. It is at the margins of these zones that the fungus is most actively grow-ng. If the disease is allowed to progress, and more than two-hirds of the stem is girdled then no treatment is effective. It s, therefore, recommended that the diseased plants should be reated soon after the exudation of the gum is noticed.

Apart from a curative treatment, gummosis of citrus can be prevented by adopting suitable preventive measures. (i) As has been shown above, the fungus enters the plant at the bud-union. It is, therefore, very important to plant young trees budded high on rootstock of *jamburi* or other resistant variety. Budding should not be less than 18 inches above the collar of the rootstock. (ii) Soil should not be piled up too high round the trunk to protect the collar from too long contact with irrigation water, because this provides very favourable conditions for the penetration of the fungus. This precaution very important in plants budded low, or planted deep n the soil, since the fungus can enter the plants at the bud-nion from the soil which harbours infection. The earth should, nerefore, be removed from the base of the trunk and piled nto a small encircling mound, so as to prevent both soil and rigation water from coming into direct contact with the trunk. ii) Excessive flooding of orchards should be avoided, as this nds to create water-logged conditions in heavy soils.

Unless the disease is so far advanced as to girdle two-thirds the trunk, it is possible to cure it. The extent to which the ark is infected should be ascertained and the surface should be

scraped with a sharp knife. The diseased bark should be c carefully through to the wood with the knife, care being taken cause no injury to the wood by this operation. The cut shou be extended at least half an inch beyond the diseased zo on all sides. This operation is the most important step, elimination of the diseased bark is an essential feature of t treatment. Creosote oil having a strength of 25 to 30 should then be applied with a strong brush to the exposed woo The application should be thoroughly made at the sides. Cre sote oil should be allowed to penetrate into the wood and t bark at the sides of the cut area so as to kill the fungus. Aft the surface of the wood is dry, coal tar painting is to be don on the exposed parts only to protect the same from wood-rotti fungi. If the diseased bark is not carefully removed, the disea may reappear at the side of the wound. In such cases, it w be necessary to cut out completely all the diseased bark and tre the fresh wound as stated above.

The creosote oil is guaranteed to contain 25-30 percent hig boiling compounds of tar to which it owes its fungicidal prope ties. It has been found that the cost of treating a tree varies relation to the extent of the wound to be treated. On an ave age, however, more than five hundred trees can be treated wit one gallon of the oil. Unlike carbolic acid which causes burn ing to the stem when used in more than the desired quantity creosote oil causes no injury to the plant tissues.

Canker

This disease is also serious and is gradually spreading Brownish pustules appear on leaves, stems and fruits. Th trouble is most common on *Kagzi* lime tree The causal agent is the bacterium, *Pseudomona citri*. The pustules are more severe in places of contact two or more fruits. It is not possible to cure citrus canker b it can be prevented from spreading by picking off all affect leaves and fruits and by pruning affected twigs. As the troub appears on the smaller twigs and then spreads downward pruning of the twigs can be done without causing much dama to the trees in the earlier stages of attack. The affected par which are thus removed should be burnt, and the whole pla should be sprayed with Bordeaux mixture (5: 5: 50) to preve further infection. Citrus canker is a notorious trouble almost all citrus growing countries (81). It probably originat

ı India or Java, whence it spread to other countries. In India, is seen in the Malta orange plantations of the Punjab and in ıe citrus groves of the Bombay and the United Provinces, engal, Assam, Madras and the Central Provinces. The amage caused by it is, however, not much, if the trouble is ontrolled as above in its very early stages.

oot-rot

Citrus trees, especially *Santra* and *Mosambi* are often seen collapse suddenly within a month or two in thriving plantations. Trees may be affected individually or in patches and may turn yellow and wilt. In few months they succumb to the trouble. When their roots re examined, they are seen to be rotting and their bark peels ff lightly and the rotten portion darkens in colour and may nell badly. Root-rot has also been found to play havoc in everal orange plantations in South India. Several plantations ave lately been devastated by root-rot. This disease is being udied further. It may be only stated at present that as soon s the tree is found to wilt, for no apparent reason, it should be t once uprooted and burnt on the spot. A trench may be dug ll round the base of the tree enclosing the region of the roots, nd the dug-up soil of the trench may be heaped in the enclosed rea. The spot enclosed by the trenches may be sterilised by urning brushwood or other material and in this way the spread f the disease may be prevented to some extent.

Vithertip

In the Punjab, a disease known as withertip caused by *olletotrichum gloeosporioides* is widely prevalent. As this disease is generally confused with citrus die-back, it is necessary to understand the characteristic mptoms that distinguish the two diseases. The withertip sease causes characteristic black dots all over the dead parts of e affected twigs, which are sharply demarcated from the ealthy parts. These dots are not seen in die-back. Bordeaux ixture spraying has proved most effective as a control measure gainst withertip.

Iottle leaf

The characteristic symptoms of the mottle leaf of citrus e the appearance of irregular patches on the leaf surface, each arising first as a chlorotic spot, and then widening and deepening in colour. The eins remain green but all the rest of the diseased leaves evelop a yellowish colour. In serious cases, the tree is dwarfed

and the yield declines. This disease can be corrected by t application of zinc sulphate or sometimes by ferrous sulphat Best control can be effected by spraying the trees with a mixtu of zinc sulphate (10 lb.), hydrated lime (5 lb.), actin ($\frac{1}{4}$ lb.), solol ($\frac{1}{2}$ lb.) with 100 gallons of water. The zinc sulpha should be 98% pure. Hydrated lime is first added and th the zinc sulphate. This is followed by actin or solol, and t mixture is briskly stirred before use. Spraying with ferro sulphate 0·0001 percent solution has also been found effic cious in some cases. Actin and solol do not seem to be essenti in all cases.

The trouble is supposed to be caused by lack of enough zi or iron compounds in the soil, which prevents normal chloroph formation. Commercial zinc sulphate is almost always close associated with the presence of ferrous sulphate as an impuri in it. A sample from the Baroda market sold as zinc sulpha showed on analysis the presence of iron sulphate to the extent 0·005% calculated as Fe, or 0·0135% as iron sulphate. Wh the quantity of iron sulphate required to cure the trouble is small as the one shown above (0·0001%), what is containe as an impurity in zinc sulphate is more than enough to effective, and it appears to be a fallacy to think that the zir sulphate is the real curative agent in all cases. Spraying of irc sulphate alone has also been found to be very effective again mottle leaf of *Mosambi* and Navel Orange trees in Barod although the effect is seen several months after spraying done. Since spraying iron sulphate reduces the cost ve considerably as compared with spraying zinc sulphate, t former is very strongly recommended to be tried first. I the Gujerat area, this trouble is rather common in citr orchards, and it is suggested that spraying of iron sulpha once or even twice in the year as a regular cultural operati be adopted both to cure and to prevent the mottle leaf troubl Spraying should be done in fair weather, when the stickin material may not be washed away by rains for some da at least.

In the Madras Presidency, spraying of mottled trees with mixture containing 10 lb. zinc sulphate, 5 lb. hydrated lin with or without $\frac{1}{2}$ lb. spreader like lime casein or skimm milk, in 100 gallons of water has proved very efficacious

·aring plantations. The disease usually disappears a few days ter spraying, and beneficial effects last for at least one season ıd possibly for longer periods. It has been suggested that ·en trees not affected by mottle leaf are benefited from this ray (164). The spray should be applied preferably when the ·e is not making active growth, since the young foliage and ·ry small fruits are liable to be affected. It was, however, seen at even when spraying was done on flowers in the stage of ·ening or setting fruits, it caused no significant damage in a *'osambi* orchard in the Baroda area. This trial is, however, ıt conclusive. When mottling is caused by water-logging, cessive salinity in the soil or defective culture, zinc treatment not expected to be of much use.

Along with spraying of iron or zinc sulphate the trees sprayed ould receive as good cultural and manurial treatments as pos- ·le in overcoming the trouble. Choudhury (54) working in e Punjab records: "Chlorosis of Malta (*Citrus sinensis*) has been vestigated. Chlorotic areas become slightly more acidic than e adjoining green portions. No correlation with the soil condi- ·ns has been found. In transverse sections, the chlorotic eas show light green chloro-plastids and in bad cases, where e regions turn yellow or whitish, breakdown of the granules seen and also the plastids degenerate and the cells become npty and collapse. Injections and sprayings with different ·n salts have been tried for curing chlorotic conditions. Fer- us sulphate in 0·00015% solutions, whether injected or rayed, has been found to be most efficacious and as spraying quires no special skill this method has been recommended."

In the Nilgiris District, Coorg, and Wynaad of Malabar, fruit and leaf fall of orange trees is very common. An at- ·ked tree gives a fœtid odour and can be detected from listance. This usually starts with the onset of the monsoon d does maximum damage in August and September. is caused by the fungus *Phytophthora palmivora* Butler.

af and fruit of orange trees

The first symptoms on the leaves and fruit are water ıked areas which gradually rot more. They are later shed in large numbers. It is usual to see large numbers of shed unripe fruits under an attacked tree.

In Coorg the disease is controlled by spraying with Bordeaux

mixture, once at about the time monsoon sets in and again October. Such timely spraying completely controls the diseas

Cracking of fruits

Cracking is noticed in limes and lemons, more than *Santras* and *Mosambis*. Cracking is the effect of irregu physiological changes in the plant tiss caused by irregular watering and manuri Considerable damage is caused to the crop by this troub but its severity is limited.

Tambera

Fruits of the *Mosambi* in plantations which are ov irrigated or which remain moist all the year round, are seen be covered with a deep brown coating. T rind is unaffected inside, and the fruit also quite good. Its appearance is, however, completely spoil and this fact lowers the market value of the fruit. The cause this trouble is the attack of mites. Spraying with lime sulph wash reduces its seriousness. Preventive measures may adopted by draining the soil of the plantation and by regulati irrigation water.

Fruit sucking moth

One of the most serious pests on orange fruits in Peni sular India, is the fruit sucking moth, which punctures a sucks the juice of almost ripe fruits. The fruit then drops aft two or three days. There are several speci of this insect, of which *Ophideres fullonica* L. quite common. It is a stout moth with upper wings of greyi colour and the lower ones conspicuously bright orange and blac These are *nocturnal* in habit, and therefore remain hiding duri the day and start feeding at dusk. In the Madras Presidenc bagging of young fruits with envelopes of palmyra leaves almost universally practised as a prevention against their attac This is quite economical. Even paper bags may be used f this purpose. The moths can also be hand-picked and destroy at night with the help of torches and this mechanical meth of control is quite effective.

Stem borer

Arbela tetraonis M. bores in the stem of orange and lem trees, mostly in old and neglected gardens. Besides these, also feeds on several other fruit trees name guava, pomegranate, mango, etc. The lar throws out peculiar patches of excreta on the bark the trees near the hole made by the borer inside. At nig it comes out and feeds on the bark. The galleries which t

arva bores and the freshly eaten bark are the symptoms of ttack. By way of control (i) syringing the burrow with a little hloroform or creosote and plugging it, and (ii) painting the ark with paris green solution of one ounce in two gallons of vater after removing the excreta and the silky material from he trunks are very effective. Two applications in a week are nough to check the pest.

The green fly attacks all kinds of citrus plants prac- ically throughout the year. Both adults and nymphs feed

phids *Toxop- ra aurantii* Boy

on the sap and growing shoots and check their growth. Such plants usually impart unhealthy appearance with lower leaves look- ng oily, and sticky due to "honey dew" secreted by the insects. lackening of leaves due to mould may also be conspicuous.

The incidence of attack is particularly serious during the nonths of October to February. In nature aphids are kept in heck by a small lady-bird beetle, red or yellow in colour with lack spots, as the adults as well as their grubs feed actively on hem. Spraying with fish oil rosin soap ($\frac{1}{2}$ lb. in four gallons f water) or nicotine sulphate (1: 800) is a very effective ontrol.

Dialeurodes citri A. is a major pest. Black nymphs are seen eeding on the underside of the leaves. "Honey dew"

Vhite flies

secreted by the pest develops a sooty mould which interferes with the photosynthesis. he pest is active from October to February and can be con- rolled by spraying with rosin compound in the ratio of 1: 6 or sh oil rosin soap (1 lb. in 4 gallons of water).

The caterpillar *Papilio demoleus* L. attacks all kinds of trus plants and *kagdi* limbu, particularly. The butterfly is

e lemon terpillar

large and conspicuously coloured and is com- mon throughout the plains. It lays small round yellow eggs singly on the top-most oots and the young caterpillars feed on tender leaves. Their lour changes from brown with white markings, to vivid een with lateral brown markings when full grown. The aterpillar pupates on the plant, fixing itself by the tail d by a thread round the body. It also lays eggs on Bel *legle marmelos)* and some other wild plants. There are several roods in a year. By way of control, hand-picking and

spraying with lead arsenate are effective. The operatior however, should be repeated at intervals.

Scale insect

Chrysonphalus aonidum Rilay is also a major pest attacking leav and fruits in the Bombay Presidency. The scale is small, rour and brownish black in colour, which spo the appearance of the infested fruits. It, hov ever, only sticks to the fruits superficially and can be rubbed c with a rough piece of cloth before the fruit is packed for ma keting. The plants should be sprayed with fish-oil rosin soa at the rate of 1 lb. in 4 gallons of water.

Leaf miner

Phyllocnistis citrella S. produces glossy mines special on young leaves. The affected leaves are disfigured wi a number of irregular, unsightly and gliste ing patches on them and a number of zigza mines are prominent. The damage caused by this insect not severe, and is confined to the affected leaves only althoug in the case of virulent attacks, the plant may suffer fro the serious dimunition of the healthy leaf area, and co sequently of the elaborated food substances. It is als believed by some that the insect is a carrier of canke infection and, therefore, its successful control is essential fo preventing the more serious canker incidence at least to som extent. Removal and destruction of the affected leaves an spraying of nicotine sulphate (1: 800) or of strong tobacc decoction, are effective control measures.

Mineral deficiency

Manganese deficiency is widespread in orange areas. Sever deficiency symptoms were in some areas associated with earl decline of lemon trees. Sprays includin manganese sulphate and soda ash 10-5-10 and 4-2-100 respectively, proved successful in some cases. I others when followed by fumigation, they showed signs of youn leaves burning (214).

As soon as slight mottling appears, a foliage spray of 4 l of zinc sulphate plus 2 lb. of hydrated lime in 100 gallons water is recommended to be applied in most places and use regularly once a year. In extreme cases, 4-6 gallons of spra containing 10 lbs. zinc sulphate and 5 lbs. lime in 100 gallo of water is recommended (243).

Abnormal drops of flowers or fruits are observed in son orange groves in certain seasons. Such drops may be cause

·uit or flower ·ops

; one or more insect pests, or fungoid diseases, weak health of e trees, insufficient supply of nitrogen or moisture in the soil, gh wind velocity, and low temperatures or sudden variations in eather conditions. Excessive stagnation of water and deep ploughing or other tillage practices that cause disturbance to the roots at the blooming or .rly fruit setting period may also cause enormous fruit and ›wer drops. In every grove, some amount of flowers and uits are bound to drop even under normal conditions and June-drop" is the term applied to the heavy dropping period hich is characteristic in American citrus orchards. The ·ower should be able to distinguish the unusual from the nor-al drop, and adopt suitable cultural practices or undertake ›ntrol measures after studying the causes operating in each ıse, preferably in consultation with the workers on fruit culture · fruit diseases and pests.

Reductions in fruit drop from 27% to 96% are reported by sing 2, 4-D water sprays at concentrations of 5 p.p.m. to 25 p.p.m. · the free acid equivalent (245).

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CHAPTER IV

GUAVA

(*Psidium Guajava* L.)

One of the hardiest of fruit trees, the guava is grown exten-
ely in India. It is essentially a tropical tree, and adapts
lf to most conditions of soil and climate prevailing in India.

roduction

The cultivation of guava seems to be fairly old in this country. Total acreage under guava India is 1,05,155 distributed as follows:—

Name of Province	*Area in acres*
United Provinces	58,454
Bihar	19,992
Central Province	10,023
Bombay	7,415
Orissa	6,000
Madras	2,500
Hyderabad	771

The original home of guava is said to be the tropical parts America. The Spaniards found this fruit tree growing in ensive regions from Columbia to Peru, when they first visited American continent. It is, however, found difficult to point a more restricted area as the original home of guava because ts spread due to natural agencies, as for example, birds in early times. It is reported that the distribution of this fruit to other countries of the world is due to the Spaniards.

The guava tree is at present found cultivated in most of the pical countries of the world. In the Fiji Islands, this fruit is considered to be an "obnoxious weed" and the Govern- nt of that country is endeavouring to eradicate it. Guava rown in California, Florida, Cuba, Brazil, Mexico and Peru, has been naturalised in the Hawaii Islands. Stray trees also found on the Mediterranean coast of France and Algeria. s a common fruit tree in Southern China and the Malayan insula. In India, guava trees are cultivated with care in

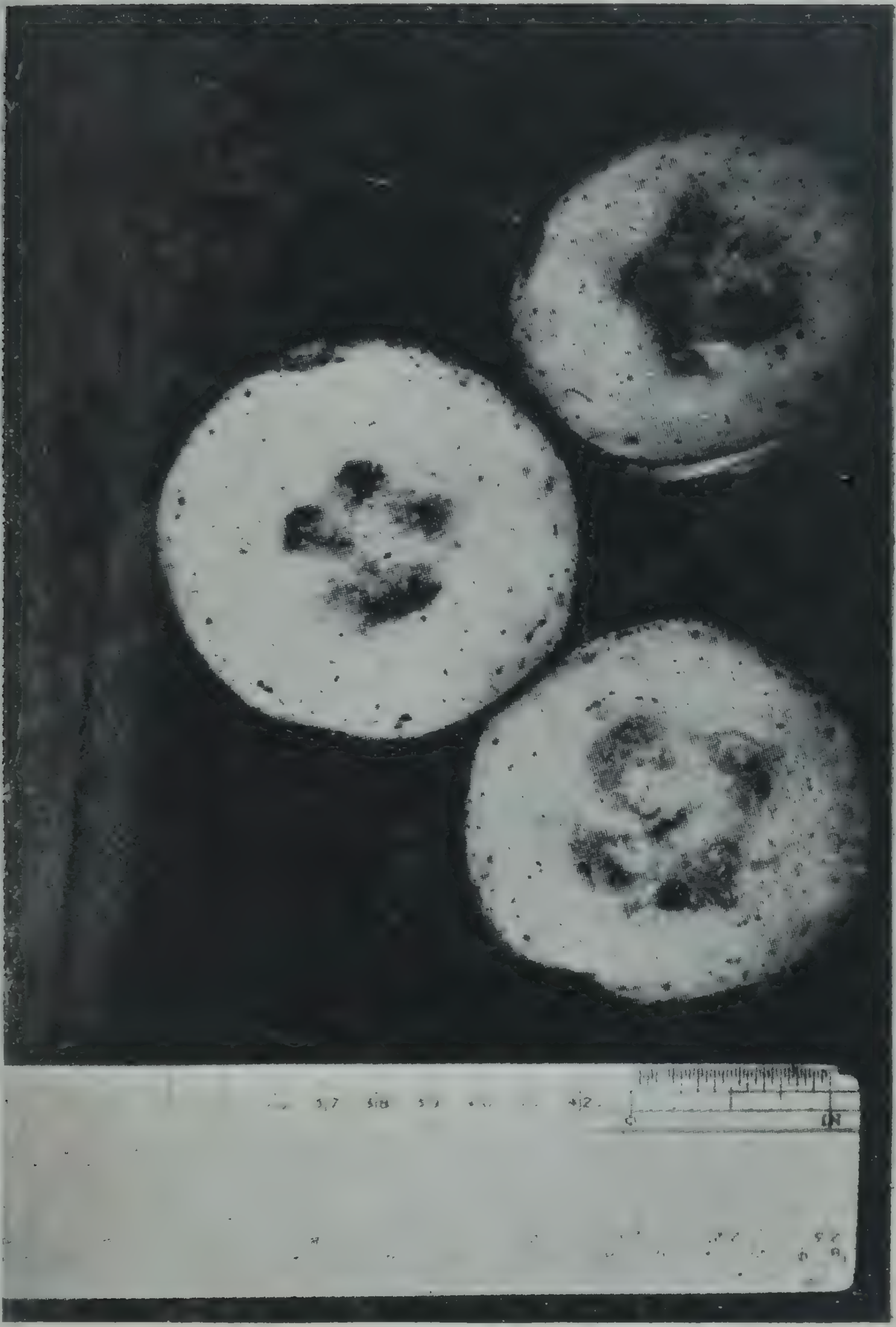
many provinces. Guavas from Lucknow, Allahabad, a Banaras are reputed for their size and quality all over Ind (20). The odour which the guava fruits possess is not consider pleasant by some people. But for this and for the hard se contained in many varieties, the guava would have becon one of the most popular fruits. With the progress of the ca ning and by-product industries, however, the guava holds o bright promise as one of the remunerative fruit crops all ov India.

Varieties

The main varieties of guava are ordinarily suppos to be two, namely, the white and the pink fleshe The former is more popular and mo extensively cultivated and has several strai showing minor differences. Popenoe (2 describes the following species:—

1. *Psidium guianense*, a white fleshed fruit deriving t alternative specific name from its origin in Guin in Africa.
2. *P. cattleianum*, or the small strawberry guava which perhaps the wild ancestor of cultivated form Variety *lucidum* has sulphur yellow fruits.
3. *P. chinense*, which is an unindentified horticultur variety.
4. *P. friedrichsthalianum* is the Costa Rican guava wit sulphur yellow fruits and with white flesh.
5. *P. guajava*, is the more common cultivated grou with white, yellow or pink flesh.

The varieties grown in India mainly seem to fall under the la species, namely, *Psidium guajava*. The fruits are principally of tw shapes, the pyriform and the pomeform. The varietal nam in this country are mainly derived from the places they con from, and it is nearly always that a local name stands for a d tinct variety. The considerable variations found in these fru are due to the fact that guava plants are generally raised fro seeds. The *Cattleianum* and Chinese guavas are cultivated on limited scale in some parts of India, but these are as yet of commercial importance. A bushy variety commonly known hill guava or wild guava, is found growing extensively on t uncultivated hill slopes of the Nilgiris and some parts of t



THE SEEDLESS GUAVA FRUITS. THE LOCULI AND THEIR UNDEVELOPED OVALES MAY BE NOTED.

Facing page 246.

ower Himalayan regions. This has not attracted much attention so far except as an inferior substitute in salad and for the preparation of guava jelly.

The principal three forms of cultivated guava obtained in the Bombay Presidency are the following:—

I. These are usually large in size, mellow and delicious and have a few soft seeds. Fruits weighing as much as a pound each may be found in this group. The Sind, Lucknow, Allahabad, Banarasi and Dholka types fall into this group.

(1) *Sind.*	Trees bushy and of spreading habit; fruit has few and soft seeds; elliptic round in shape; normal number of loculi is reduced and filled with white or reddish pulp. Quality of fruit very high.
(2) *Lucknow.*	Tree bushy in growth, and the fruit is long or occasionally long with ridges on the surface. Seeds are few and soft. Pulp slightly acidic even when fruit is fully mature.
(3) *Dholka.*	Tree is vigorous in growth and the fruit is fairly big; seeds are few and soft.

II. These types are hardier and more seeded than the above. They include the Nasik, Dharwar, Miraj and Limbgaon varieties.

(1) *Nasik.*	The tree is erect in habit and bears bottle shaped fruits, with distinct long neck. The fruit has a rough skin and keeps well.
(2) *Dharwar.*	The tree is bushy with elliptical hard fruits, which taper towards the stalk end. Seeds are many. Fruit keeps well. This is the type of fruit grown all over the Deccan and Karnatak, at Limbgaon and Miraj, as well as at other places. Each tract claims its product as superior in quality with little attempt for justification.

III. Stray plants of *Psidium cattleianum* as well as anoth cultivated type, which has practically no seeds i it, are often found in the Bombay Presidency. Th seedless type is lately being propagated vegetativel on a large scale, and distributed for large sca planting.

It would appear that the northern types are generally o better quality, although the southern types keep well for a fe days longer, which is no small consideration in marketing s perishable a fruit as the guava. In the United Provinces, number of distinct guava varieties, such as *Hafsi* and *Karella*, ar popularly recognised. But the distinction between these varieti has yet to be defined.

Soil

The guava tree grows well in sandy and alluvial soils, whic have an admixture of clay in them as in parts of Sind. Th black and light *goradu* soils of Gujerat are als suited for it as well as the fertile alluvial depo sits of river banks. In the Deccan, guava plantations are see in deep black, medium black and ill-drained soils, althoug the lighter and better drained soils are highly congenial to them The banks of the Krishna, the Bhima and the Godavari river have large guava plantations along them. The black, red an brown loamy soils of the Karnatak including the stony shallow soils near Dharwar have all got thriving plantations of thi fruit tree.

Climate

The guava tree grows and fruits well in places o extremes of climate as in Sind, where the maximum tem- perature during summer rises up to 114°F, and the minimum falls to 40°F during the winter. The annual rainfall is hardly over seven inches. In the Gujerat, where the range of temperature i narrower (50°F to 112°F) and where the average annual rain- fall is more (29 inches) than in Sind, guava fruits of ver high quality are produced. In the Deccan and the Karna- tak districts, where the temperature ranges are still narrower and where the monsoon is stronger, the guava plantations d thrive equally well. On the slopes of the Western Ghats wher the rainfall is very heavy, stray trees of guava are seen growing and bearing irregularly. Being a tropical tree, the guava plan can be grown almost in any part of this country. It thrive

GUAVA TREE OF LUCKNOW 49 STRAIN.

etter and produces quality fruits, when grown in places of ex-emes of climate than in those of equable climate. This hardy ee is not much affected by cold waves, which occasionally sweep ver the Deccan and Gujerat tracts.

opagation

Guava plants are propagated generally by seeds in the ombay Presidency. However, certain trials conducted at the Ganeshkhind Fruit Experiment Station, Kirkee, have shown that seed propagation gives se to considerable variation in the form and size of fruits, the ature and flavour of pulp, seediness, and other morphological haracters such as the spreading or erect growth habits of trees. uava plants are, therefore, propagated lately by grafting, narching being the most common method adopted) in the rogressive nurseries of this country. Budding is also found ossible in guavas. But this method is not yet widely adopted. is noticed that layers and gooties prepared on fairly mature ems also strike roots and produce good plants. It is also possible propagate from root cuttings or suckers which spring from e roots. Stem cuttings are not very successful.

For grafting, rootstocks are raised by sowing seeds in raised edbeds at the commencement of rains. Guava seeds are und to keep well for a year or more, without their power of rmination being much affected. Seeds are obtained from rdinary fruits which ripen on the trees. They are cleanly ashed and dried in shade, and mixed with fine wood ash. On rying, the seeds are stored in properly closed tin boxes and pre-rved in a cool place until they are required for use. Seedlings re transplanted in pots when they are about six inches tall. The eaker seedlings are rejected and the more vigorous ones are one selected for potting. This selection gives a good start to e seedlings and they turn out to be good rootstock plants. he pots are prepared in the usual way with a layer of pot shreds the bottom hole and a layer of well-made compost over it. he compost may be similar to that mentioned under mango. ransplanting can be done at any time under orchard conditions, but the plants require to be placed in shade and watered diciously until they establish in the pots. The soil in the pots as to be stirred at least once a month, and some kind of liquid anure added to it after each stirring. The side shoots have be pruned as soon as they appear, in order to obtain a strong

straight rootstock to graft upon. Guava plants can be got rea in this way in about a year from sowing.

Enarching is the common method of grafting followed, a it is best done during monsoon, when there is a slight break rains. The plants are then in sap-flowing condition and gra "take" readily. The scion should not be separated for at le three months from the time of grafting to ensure successful uni When the scion is separated from the parent plant, the graft kept in shade for some days to harden. If the scion withers i few days, the graft is not successful, and the rootstock may used again for regrafting. If it does not, then the rootstock headed off above the graft-joint. The graft is then ready sale, but it is preferable to harden it for about three mon before planting it out in the open field.

In Ceylon (23), the guava is propagated by gooty and layering. In the Malayan Peninsula this tree is generally pr pagated by seeds.

A method of propagating guava very rapidly and with lit trouble is to use suckers which may be forced to appear, if desire Lateral roots are exposed about two to three feet away from t main trunks of the trees and cut wounds are made on the In course of time, these roots throw out suckers from their do mant buds. When the suckers grow to a suitable size, th may be severed from the mother tree together with a portion the roots and transplanted in their permanent place. This pra tice is not, however, much in vogue. Du Preez (8) suggests th guavas should be propagated by layers, root cuttings, har wood cuttings or suckers, as the seedling progeny even from single selected fruit is very heterogenous.

Budding as a method of propagation has not shown promi in South Africa though it succeeds well in Florida, Californ and Java (8). A few attempts made to bud upon well-grov rootstock plants at the Ganeshkind Fruit Experiment Static Kirkee, met with considerable success. The method adopt was the shield budding.

Planting

The land in which guava plants are to be grown, prepared by clearing all brushwood growth, ploughing a harrowing several times. It is properly levell and green-manured by growing sann hen (*Crotolaria juncea*) in the previous season. Pits are then dug

ie land at required distances during the hot weather and left pen to the sun and wind for a few months. Pits are generally iken fifteen feet apart except in the Gujerat tract where the lants are spaced at twenty feet apart. Pits may be of two feet by vo feet by two feet, or they may be three feet cube. The soil of the p half of the pit is kept separately from that of the bottom half, ith the belief that the latter is properly weathered by the time is required to fill the pit. Any kind of brushwood material iay be burnt in each pit to improve the texture of the lower iyer of the soil. Before the rains start, the pits are filled with ie original soil, mixed with about fifty pounds of old and well otten cattle manure. While filling the pit, the top soil is placed t the bottom and the bottom soil is filled on it. In fertile soils, dditional manure is not necessary while planting. As soon as ains commence, planting is done by using seedlings or grafts s desired. Grafts of superior varieties are to be preferred to edlings, as the latter cannot be depended upon to produce uality fruits. While planting, it is advisable to prune the tener shoots of the plants, as otherwise they may dry up on account f the shock which the young plants receive when the roots are isturbed. In the Dholka (Ahmedabad) tract four or five seedng plants are planted in each pit, but this is not recommended s the plants get crowded in no time. If grafts are planted, the raft-joint should always be kept sufficiently above the ground vel. Watering follows planting immediately, unless it rains, nd is copious in the beginning.

igation

The guava is a very hardy tree adjusting its water requireents remarkably to the hot and dry conditions prevailing in the Deccan tract. The chief economic consideration which encourages growers to go in for iava cultivation is that, this tree does not suffer much if it is not atered during the hot months, when wells usually go dry. It however, found that where the plantation receives better care id more irrigation, the yield of fruits is heavier and the fruits e of higher quality than where the trees are neglected in the ier part of the year, as it usually happens. Irrigation ought be given copiously on planting. Then it follows as required ice in ten days or so, except when it rains. It is continued roughout the year for the first three or four years, according to the availability of water during the hot weather. After

the tree begins to bear as it does in its third or fourth year, i gation is given only during the bearing period. Guava pla bear flowers soon after the rains start in June, and the frui harvested by January in the following year. From Febru to June following, the trees are practically left to themselves.

There are two systems of irrigation in vogue in guava plan tions, namely, the ring or the basin and the bed or check syste Irrigation in furrows is rarely adopted. In the ring system, a l mound of earth is raised at the base of the trees and water is giv in a shallow trench round this mound, so that the irrigation wa is prevented from touching the trunk of the trees directly as v explained already under citrus fruits. Moreover, this system c be adopted to irrigate trees exactly where the feeding ro lie, increasing the spread of the mound as the trees grow in si This system also economises the quantity of water required irrigation. The bed system consists of irrigating trees in circu beds at the base of trees, in which case the trunk comes into dir contact with irrigation water. As the whole bed is filled wi water at each turn of irrigation, this system consumes mo water also. Although the usual practice is to irrigate in be the ring or the sloping basin system is found to be more suitab As a result of trials conducted at the Ganeshkhind Fr Experiment Station, Kirkee, it is found that guava trees can well with seven to ten irrigations per year, consuming there fourteen to twenty acre-inches of water in addition to the annu natural precipitation which comes to about twenty inches on

Manuring

Manuring is one of the most important operations in t cultivation of guava trees as it is in all fruit trees. Farmyard cattle manure is the most common manu used in the Bombay Presidency, although some tracts an additional dose of other manures is also given. F example, wood ash is used in seed beds in Baroda and Poo with a view to raise good seedlings. Tank silt is applied Dholka and sheep dung is sometimes used in the Karnata Seedlings grow to about two feet high in the course of a ye and become fit for transplanting in the field if these manu are applied. At the time of transplanting of guava plants sor manure is usually given. In the Baroda territory, a small qua tity of common salt is added to each pit along with about fo ounces of castor cake. These manures are meant to countera

GUAVA SHOOTS IN FULL BLOOM. FLOWERS ARE BORNE ON NEW SPURS.

Facing page 253.

the white ant trouble which is so common in the Gujerat area. The use of three to four pounds of castor cake and about forty pounds of cattle manure per bearing tree per annum is found to give very good results in Karnatak. After the trees are planted in the field, they receive no manure during the earlier stages of growth, when inter-crops are raised between the rows of the main crop. The plants are regularly weeded, manured and irrigated along with the inter-crops. When the trees are treated for the crop (*bahar*) the above dose of manure is given and the roots are covered up. Guava trees readily respond to the care they receive and yield accordingly.

Inter-crops

Guava trees, it has already been stated, are planted fifteen to twenty feet apart each way. This leaves some open space in which other short-lived crops may be taken during the first few years of the plantation until the main trees spread out sufficiently to occupy the whole area. Inter-crops usually consist of some seasonal vegetables or other agricultural crops such as *guvar* (*Cyamopsis psoralioides*), *bhendi* (*Hibiscus esculentus*), onion (*Allium cepa*), turmeric (*Curcuma longa*), etc. In the red soils of the Dharwar district, dry crops of legumes and millets are also grown. At Limbgaon in the Satara district, turmeric, onion, garlic (*Allium sativum*) and such other vegetables are grown during the monsoon. In the Poona district, where vegetables command a good and ready market, various leaf and fruit vegetables are grown. In the Gujerat tract, lady-finger (*Hibiscus esculentus*), brinjal (*Solanum melongena*), chilli (*Capsicum* sp.), ginger (*Zingiber officinale*), cabbages, knolkohl and other vegetables are taken.

Treatment for *bahar*

Bahar or the production of blossom generally occurs when the trees put forth new shoots at the beginning of a new growing season. The existence of three distinct growing seasons in the Deccan and the peculiar phenomenon of some trees producing blossom thrice a year has already been pointed out under citrus fruits. Guavas also respond to the various practices like withholding irrigation water, and exposing feeding roots and pruning the fibrous ones, that are applied in the Bombay Presidency to force out blossoms in any of these three seasons. Guava trees come to bearing in the third or fourth year of planting. They can then be treated for bearing a regular crop. The treatment is generally

given to induce blossoms in the *Mrig bahar* (June-July), t chief idea underlying this treatment as was pointed out in t case of citrus trees, being to check vegetative growth of the tre and to induce fruiting. Since the guava trees have a te dency to produce blossom at every change of the season, as e plained above, they may produce some blossom three times year under natural conditions. In order, however, to conce trate the crop, in one season, the trees are artificially reste for any one of the three flowering seasons. The October flowe ing is, however, difficult to treat for, owing to the precedi rainy months, when it is impossible to withhold irrigation wat for resting the trees. This *bahar*, locally called the *Hatti bah* is, therefore, mostly missed. The third *bahar*, namely, *Am bahar*, or January-February flowering is also not popular, as th requires the trees to be irrigated during the hot months, whe wells go dry, and as the fruit is harvested during the rains whe they have little demand in the market. The hot season durin which water is usually withheld, induces the plants to "dry up and shed most of their leaves. Before the rains, the orchar is ploughed and cross-ploughed, and cleaned of all the dry an dead branches on the trees. The trees are also examined an treated for stem borers, or other insect or fungoid trouble. I simple withholding of irrigation water does not sufficiently chec vegetative growth of the trees, as it happens in some deep blac retentive soils, the roots of the trees are exposed to make th treatment more severe and effective.

Root exposure in the case of guava trees consists of openin out the soil at the base of the trees in a circle within a radius o about three or four feet from the trunk, and to a depth of abou eight to ten inches. Removing the soil in this way exposes the feeding fibrous roots as well as some of the conducting one The smaller and injured roots are neatly pruned an any severe wounds caused to them in digging the soil ar trimmed and the cut ends are smeared with coal tar to hel healing and to prevent infection of harmful soil organisms The roots are left exposed for about a fortnight or more if re quired, until the trees shed some of their leaves or show sufficien signs of wilting. When roots are exposed the annual dose o manure is added to the soil, which is opened out and at the en of the period of exposure, the soil mixed with manure is replace

ı its former place. Irrigation beds and water channels are repared and watering commences on about the tenth of June. 'he first few turns of irrigation are sparing, as in citrus lest the new ush becomes vegetative growth, suppressing the appearance f blossom. After the third irrigation turn, normal water once ı ten days or so is resumed, unless it rains during that period. rrigation continues till the end of the harvesting of the whole rop, that is, up to February. The usual practice in adult plan-ıtions in the Deccan is to leave the guava orchard to itself with-ut doing any operations in it from February until the end of ıpril or thereabout, when treatment for *bahar* again begins.

During the resting period cultivators resort to bending ıe branches of guava trees, with a view to check the upward flow of sap and in order to stimulate dormant buds on thicker stems to produce blossoming buds. Bending" consists of tying together branches of adjacent trees ı a horizontal position. This operation is practised in alternate ears. Branches of guava are naturally flexible and spread ut freely if left to themselves. By bending the middle parts, ıe branches are strained and dormant buds on the thicker parts specially get stimulated to growth activity. Such sprouts bear owers and produce fruits.

ending

The system of bending branches as a means of forcing guava ees to fruiting, as explained above, is not economical under the resent conditions of cultivation, as it involves considerable extra ıbour and hinders free inter-tillage. The branches might also reak in the attempt to bend them. When repeated several nes, the bending treatment leaves the trees with a number of caying stumps of broken branches which admit infection of in-ct and fungus troubles. The plantation gets crowded up in time, hindering all operations of cultivation and even free ovement in the orchard.

In order to avoid this condition of bent-tree plantations, the epartment of Agriculture, Bombay, undertook investigations to ascertain if a suitable method of pruning can be substituted for the practice of bending. The ethod of pruning found most useful was to cut off the previous ason's growth leaving only a couple of buds on it at the base. he pruned branch, in other words, would be left with a stump about three inches in length carrying two or three buds on it.

uning

As the top is no more able to utilise the sap sent to these stump the buds which were till now semi-dormant, are stimulated ar they put forth new sprouts. The new sprouts produce blossom ar the new season's crop. Pruning for fruit spurs is best done the month of May when the trees are resting, and before th rains set in. Irrigation is given two or three weeks after prunir when the buds start growth, to bear flowers in about a mont If rains are late and irrigation water is scarce, the natural grow is scanty and flowering is retarded. The results obtained d not show any considerable increase in the quantity of fruits born as a result of pruning. The investigations were further followe up during 1921-1924. Individual tree performance was r corded. The comparative study of the yield records of six hu dred pruned and unpruned guava seedling trees showed that th total number of fruits per pruned tree is only half of that of th unpruned trees, but the size and the quality of the former we much improved. The fruits on pruned trees, therefore, com manded a higher market price. Pruning has other advantag in that, bearing of the plants is hastened in the season resultin in early harvesting. The pruned trees are seen to flower earli than unpruned ones under uniform cultural treatments. Prun ing also gives protection to fruit against bats, birds, etc., b affording good shelter to the fruits hiding them from the sight birds by the vigorous leafy growth of trees. The growers' metho in the Poona and Satara districts to bend and tie together the ou going lateral branches of neighbouring trees in order to stimula dormant buds on these branches to sprout, neither lends an shape to the trees nor restricts the growing size of the trees to an extent.

In a trial at Allahabad, guava trees planted 25 feet apar were pruned lightly; others at 15 feet apart were pruned heavil The heavily pruned trees produced larger fruits, but the nur ber of fruits per tree was so low that the yield per acre was le than half of that of the lightly pruned trees. The hea pruning thus proved entirely uneconomical (16).

Guava trees are sometimes trained to shape. Trainir may consist of cutting off dead and dry branches and of nippir

Training

off the suckers. The shoots in the interior whi would crowd the "head" of the trees may al be removed in order to get an open-headed plant. Gua

trees lend themselves to training easily. Their shoots have a large number of buds, and flowers are borne in very definite positions on the current season's growth. Long branches are thrown out generally if trees are left to themselves. With a view to induce more new shoots which would bear flowers by exposing mature stems fully to light and air, the espalier system was tried in comparison with the untrained tree. Each plant was made to carry only three lateral branches by nipping other side growths. These branches were taken at a height of 2½, 4 and 5½ feet respectively from the ground level. They were tied horizontally to thin wires fixed to posts planted at regular distances as in a fence. The tender guava branches bend well, and can be conveniently tied to the wires fixed at any required height. When they mature and grow in size, they keep up the horizontal position permanently and do not need further support of the wires. These main branches are termed "horizontal laterals". Vertical branches are induced to grow on these horizontal laterals till they meet the higher laterals, with the result that the whole structure looks like a net-work screen. Fruiting spurs are encouraged to grow on all these branches by keeping spurs in check. They are pruned annually leaving a few basal buds as mentioned previously. Plants in a row are allowed to throw out laterals only sideways along the rows, and the ends of such laterals often meet.

As a result of observations over several years, it is found that the above system of training guava plants does not ensure adequate bearing of the trees. Pruning the annual growth is found essential to encourage fruiting spurs and several bad knots are formed on the trees, encouraging borers and birds to feed on them. This system is, however, very suitable to small compounds of residential buildings where a few guava trees can be grown by the side of walls or where they can be trained to divide different sections of the garden without themselves occupying much space. In such cases, the trees would bear a small crop of fruits annually, which will be appreciated by the owner for home consumption.

At Kodur, on the other hand, it was observed that the trellis trained guavas have certain desirable features which entitles this method for a much greater popularity than it enjoys at present. Untrained guava trees become unthrifty under average soil and

care, and pruning of shoots is neither done nor is feasible on larg trees which have been allowed to grow to an irregular shap When trained on trellis, annual pruning is done both to maintai shape and to produce a succession of fruit bearing shoots. Ti about the tenth year, such guavas have been found therefore t possess a more thrifty performance than untrained guavas.

Improvement of guava

As guavas are commonly raised by seed in the Bombay Presi dency, they have resulted as already stated, in very inferior type of trees bearing crops of low grade fruits. Thi brought up the question of improving then with a view to evolve a strain or strains o guava which would have soft but few seeds, large quantity o edible pulp, pleasant flavour, good yield, and medium size, with an attractive appearance for the market. Investigations with this end in view were undertaken at the Ganeshkhind Frui Experiment Station, Kirkee, in an orchard having 600 guava seedling trees. These seedlings were planted in four plots and were all almost 14 years old, when observations regarding their individual performances were recorded. Great care was taken to maintain uniformity in cultural operations. The fruits of each tree were harvested separately, graded, counted and weighed. As a result of these observations, guava seedlings have been found to exhibit a large number of variations. Variation in the seed content of the fruits of individual seedlings is specially marked. Instances of bud variation are also not rare. Guava trees have thrown out variegated growths which have been vegetatively propagated as such and are being grown as ornamental plants.

Rolf (27), however, mentions that guava comes fairly true to seed so far as the general qualities of the class go. But experience in the Bombay Presidency does not support this view. Seedlings vary widely both in fruit quality and yield. Observations recorded at the Ganeshkind Fruit Experiment Station, Kirkee, based on the studies of individual seedling guava trees help to classify the trees under three main heads, namely, constantly high-bearing trees; irregularly bearing trees; and constantly shy-bearing trees. On the basis of records of productivity of individual trees as well as other qualitative characters as mentioned above, several high-yielding strains of good quality of guava have now been isolated. They are being propagated.

vegetatively to prevent the quality of fruits borne by the progeny from deterioration. Out of these selections, the strain, named Lucknow 49, has stood further trials in the field on a fairly large scale for its high productivity and superb quality.

Brief descriptions of some of the selected strains are as follows :—

Nasik No. 88. Trees of medium size, with open habit of growth. Bark of stem smooth and ashy grey; leaves elliptical lanceolate and slightly folding at night; fruit pear-shaped or pyriform, colour golden yellow when fully ripe; seeds few but hard; pulp sweet but slightly acidic.

Lucknow No. 49. Ascendant shrub with flattened top and vigorous habit of growth; leaves elliptical lanceolate; fruit large and spherical in shape; fruit colour bright yellow when fully ripe; pulp milky white, sweet and of agreeable flavour; superior quality of fruit but of poor keeping quality.

Lucknow No. 46. Small sized tree among the Lucknow group; low habit of growth; bark ashy grey with greenish patches; leaves elliptical lanceolate of large size; fruit of medium size, but oval or bottle-shaped, skin smooth and yellow; pulp very delicious with very few soft seeds.

Lucknow No. 24. Plant is medium-sized with an open habit of growth; leaves lanceolate and half-folded, light green and longer than those of the other Lucknow types; fruits ovate with narrow furrows on the surface; when fully ripe, colour is yellowish with a tinge of rose; seeds few and soft; pulp is rather insipid in taste but is not disagreeable.

Dharwar No. 34. The tree is compact and cylindrical in appearance with erect branches; leaves elliptical lanceolate, and half-folding, fruit medium sized with sprinkling of red when ripe; seeds hard and many; pulp is sweet.

Sind No. 63. A medium-sized tree with a smooth and dark brown bark; leaves elliptical lanceolate, light green

in colour, and with folding habit; fruit develo yellowish-green colour when ripe; seeds few a soft; pulp milky white and thick; tastes well.

Kothrud No. 19. Medium-sized tree with an open and ere habit; leaves lanceolate; fruit large in size, pea shaped, with a narrow neck and rough surfac colour of fruit white when ripe; seeds are many b soft; pulp acidic sweet.

Dholka No. 7. Tree of vigorous habit; fruit is big wit soft and few seeds; pulp slightly acidic, with swe and good flavour.

These selections have all been propagated vegetatively an planted out at the Fruit Experiment Station, Kirkee, and a now under field trial. Lucknow No. 49 has already becom popular for planting in orchards.

Yield of guava trees

The yield of trees varies according to the nature c plants and cultural practices adopted. The money value c yield further depends upon market condition and on the situation of the plantation

Life of guava plantation

In the Dholka tract (6), guava trees are almost con tinuously irrigated, sometimes even when the trees are resting The maximum period of stoppage of wate to them in this tract is a month, whe the trees rest. It is found that perhaps du to over-irrigation, guava trees in the Dholka area do not live long. For about twelve years they bear well, and degenerat after that age. The water is given here about twelve times i the year in addition to what is received through rains. Guava trees of fifty years or more in age are seen near Ahmedabad Some plantations in the Deccan are very old too, perhaps olde than in Ahmedabad.

Rejuvenation of old guava plantations is achieved in th Khandesh districts, especially near Dhulia, by heading the tree back almost to the base of the trunk. The low stumps thus left produce vigorous growth and a fair head is formed again in abou two years from pruning. Gradually, these new shoots begin t bear fruit, and often they may yield about 200 to 300 saleabl fruits per tree.

Guava fruits come to harvest in November, and th

arvest may last up to February in each year, if the trees bear *Mrig bahar* crop. *Ambe bahar* fruits ripen in the rainy season, when there is little demand r them. When fruits are fully mature, they develop a yellowish olour, and become soft to the touch. Guava fruits are mostly icked by hand, as it is not difficult to bend the branches to ick them when required.

Iarvesting

The fruits are delicate and get damaged by rough handling nd by dropping from the tree. In the Dholka region, uits are always picked with a piece of stalk and leaves on iem. This helps packing the fruits in the baskets as the aves form a sort of cushion and packing stuff. In Hawaii, the ain harvesting season for guavas lasts from June to October, lthough a few fruits may be available at other seasons.

Bamboo baskets similar in shape to those used for packing ranges are made use of in packing guava fruits. But guava askets are of a much larger size than orange baskets and hold 00-400 fruits each. Dry banana leaves are used for packing nd for covering the top of the fruit layers. The basket is ien labelled and despatched to the market. At Dholka, fruits re all laid in layers in large shallow baskets with straw for acking in addition to the stalk and leaves of the fruits. The hole basket is then covered up with an ordinary piece of cloth nd carried to the local market for sale. At Dholka the growers ack large fruits in baskets, while the small ones are sent loose in ullock carts.

Guava analysed by Chace et al and quoted by Winton and nton (34) contains 21·32% total solids, 12·94% insoluble solids, 0·88% protein, 0·77% citric acid, 4·49% invert sugar, 0·45% surcose, 0·69% total ash and 77 ml. of 0·1 N acid per 100 gm. uit ash alkaline. It is very rich in Vitamin C content.

ood value and omposition

Chace (3) found 0·84% of ash in the pulp of guava. The rcentage of constituents as found by him are: K_2O 55·00%; aO 2·48%; MgO 1·64%; P_2O_5 8·29%; SO_3 3·58%; SiO_2 3% and Cl 5·33%.

Daniel and Munsell (7) report the quantitative data of vitain content of guava as below:

Vit A 200 (international units)	Vit C 300 (Skermar units)
Vit B 14 (,, ,,)	Vit G 35 (,, ,,)

Composition and Nutritive Value of Guava

Name of food	Botanical name	Moisture %	Protein %	Fat (Ether extraction) %	Mineral Matter %	Fibre %	Carbohydrate %	Calcium (Ca) %	Phosphorus (P) %	Iron (Fe) mgs %	Calorific Value per 100 gms.	Carotene (International vitamin A Unit per 100 gms.)	Vitamin B (I. U. per 100 gms.)	Vitamin C (mgs per 100 gms.)	Calories per ounce
Guava, country	*Psidium guajava*	76·1	1·5	0·2	0·8	6·9	14·5	0·01	0·04	1·0	66	Trace	—	299	19
Guava, hill	*P. cattleianum*	85·3	0·1	0·2	0·6	4·8	8·1	0·05	0·02	1·2	38	Trace	—	15	11

The work done in India on the Indian fruits revealed the lowing composition, mineral constituents and vitamin content the country and hill guava (21). (See page 262.)

Data collected at Riverside are discussed by Webber (32). esh, colour, and degree of acidity as judged by taste have correlation with vitamin C content. There is a slight indica-n that within any variety the early ripening fruits will contain lower concentration of vitamin C than its late-ripening fruits. ost of the data collected on the ripening of this fruit indicates at the vitamin C concentration is likely to reach its peak in the riod during early ripening, when the fruits are still firm t are starting to go light yellow.

Guava fruits are generally full of seeds, and therefore, may found unfit for canning. Recently, however, it is found that

nning

with the improvement of guava varieties, the central core or seed-ball could be removed sily. The outer layer of pulp is utilised for canning. Fully ture fruit with a degree of maturity to be determined through perience, is peeled after thoroughly washing and cut into lves and quarters, depending upon the size of the fruits. the fruit is too full of seeds, it is sometimes cored. The eled fruit is kept in 1% brine solution to prevent darken-g. It is packed in plain cans and filled with 40° Brix hot up. The cans are exhausted for 5-7 minutes and sealed at a nperature of 180-185°F. The sealed cans are sterilized in iling water for 20-25 minutes and then cooled in cold run-ng water.

Guava jam is a delicious product which has lately been on the market in the Bombay Presidency. In making jam,

ava jam

all the pulp is separated from the seed, and pieces are cut small and cooked with about f the quantity of water. When the pieces are soft, an al quantity of sugar is added to the cooked pulp, together h a little of lime juice for flavour. The whole mixture then cooked again, until the temperature rises to 103°C, until the material gains a fairly thick consistency. The duct is then removed from the fire and poured into clean l sterilised containers, which are packed and stored away il required for use. A little melted paraffin may be poured the top of the jam in the containers before closing.

Guava jelly

For preparing jelly, slightly under-ripe but fresh fruit washed, cut into slices discarding the damaged portions and equal quantity of water added together with ounce of lemon juice or a pinch of citric a for every lb. of the fruit pulp. It is boiled for half an hour. T juice is pressed out with the hand through a thick cloth or jel bag, which is then allowed to settle overnight and the clear ju syphoned off. A tablespoonful of clear juice is tested with equal quantity of 95% alcohol or methylated spirit. Formati of bulky gelatinous almost solid mass indicates rich pectin, few large pieces of gelatinous precipitate indicate medium pect and a small amount of flaky precipitate shows poor pect Amount of sugar to be added is directly proportional to t amount of pectin, *e.g.*, to every cup of juice rich in pectin added one cup of sugar, to that of medium pectin half a c and to that poor in pectin, sugar is added only when the jui gives satisfactory test after concentration by boiling. The jui with the sugar is boiled (removing all the scum) till the te perature is 221°F or it satisfies the *sheeting test*: Dip a spoon the jelly and then allow it to drip from above. If the drops a syrupy the jelly is not sufficiently concentrated but if the jel drops in flakes, the jel point has been reached. Hot jelly is pour into sterilized bottles which are capped immediately. Melt paraffin wax is then poured over the surface of the cooled ma to prevent spoilage.

Guava cheese

Fresh, fully ripe fruit, after washing, is cut into sma slices and boiled to softness with an equal amount of wate The pulp is meshed through a fine mosquito n cloth. For every pound of the strained pul weigh out sugar: 1½ lb., butter: 2 oz., citric acid: 1 gm., sal half teaspoonful and colour (edible) just enough to impart attractive appearance to the finished product. The ingredie are thoroughly mixed and cooled till sufficiently thick for sprea ing and cutting into pieces of desirable size, which is done in china plate smeared with butter. After cooling, the pieces a wrapped individually in special wrapping paper and then stor in closed jars.

The guava, being hardy, is not much affected by ins pests and fungoid diseases. Birds are in fact a more serio pest to guava fruits. The chief insect pest is the sca

'ulvinaria psidii M. which infests both the foliage and fruits.

'ests and diseases

It is more serious during summer. It is a small pale yellow or green insect found in olonies. At maturity, a woolly growth full of eggs develops on ıeir back. The remedy against this pest is to spray the trees

cales

with fish oil rosin soap one lb. to 4 gls. of water or crude oil emulsion 12-15 lb. to 100 ls. of water. Two sprayings will be enough to control the pest, ' the under surface of the leaf is washed.

Birds like parrots, minas and crows all damage the semi-pe fruit on the trees. Watching and scaring the birds away

irds and mammals

during day time is the only remedy against them. Flying foxes, monkeys and bats attack uava plantations for the fruits in large numbers. Watching uring night is very essential during ripening season of fruits. iring crackers at night often minimises their attack.

Fruit flies, namely, *Dacus ferrugineus* F., *Dacus zonatus* S. and *acus ferrugineus dorsalis* H. infest these fruits very frequently and

ruit fly maggots

lay eggs in them. By the time the fruits are picked for marketing, maggots of different zes are developed inside, although it is difficult to distinguish utwardly a maggot-infested fruit from a healthy one. No medy is yet seen to be effective against the flies although a ait prepared from lead arsenate and molasses or clensel is found serve a good lure for them, as stated previously under the Iango. Disturbing the soil under the plants and exposing the upae also help in reducing the attack considerably.

The stems are often attacked by borers *Arbela tetraonis* Moore ıd the caterpillar. The grub bores the branches which

em borers

are killed. As a control, either the borer is extracted with a thin wire and then the hole sed with mud, or some cotton wool may be dipped in trol, chloroform, or carbon bisulphide or even in ordinary rosene oil and inserted into the hole. The vapours of the latile material suffocate and kill the insect inside the gallery.

Fruits of guava are sometimes seen shrivelling and turning own. Such fruits were identified as being attacked by anth-

ıthracnose

racnose. This disease has also been noticed in California, Florida, and Mexico, and curs in some parts of India. The disease is distinguished by

circular round decayed areas on the fruits. The disease caused by the fungus *Gloeosporium psidii* Delaer. As the fr decays further it gets badly wrinkled. Spraying of Bordea mixture is effective against this disease.

Guava canker is another serious disease of guava and is ca ed by *Physalospora Psidii* Str. and Pierce. It has also been repo ed from Poona. Infection originates in t bark and spreads rapidly along the stem fro one branch to another resulting in desiccation, cracking, decor cation, death of the affected parts and finally of the whole tr Numerous perithecia of the causal organism are found scatter over the dead bark. The disease has not been reported fro any other parts of the world. No control measures have y been devised.

Guava canker

Scab of guava is common not only in Bombay but other parts of India as well. The fungus which causes scab known as *Pestalotia psidii* Pat. It mainly attac the unripe fruit on the surface of whi dark pea-sized *scabs* are produced. These disfigure the fruit ar lower their market value. The disease has not been investigat and control measures are yet unknown.

Scab

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CHAPTER V

POMEGRANATE (*Punica Granatum* L.)

Pomegranate belongs to the Natural Order *Punicace*
Punica being perhaps the only known genus of the famil

Introduction

The fruit is locally called by various name such as "*Dalimbada hannu* (Kannada), *Dalin* (Marathi), *Dadam* (Gujerati), *Anar* (Hindi)." It is a popul fruit and is much liked on account of its medicinal value an distinctive taste as a table fruit.

The original home of this fruit is not yet definitely know but is believed to be somewhere in the mountain region of th

Origin and distribution

south-west of Asia extending between Kashm and Arabia. The pomegranate is grown to a extent in California and Florida, in Mexic South America, Spain and other Mediterranean countries, Egyp and other parts of North Africa, Arabia, Palestine, Persia, Afgh nistan, Baluchistan and many parts of India, Burma, China an Japan. It thrives very well in all tropical and sub-tropic countries. In Russia a midget kind of pomegranate bearin flowers profusely is said to be grown in pots for decoration.

The north-western parts of Pakistan are noted for the pr duction of high class pomegranates. The fruit which come down to the south from Kabul and Baluchistan is considere extremely fine and commands high price. This fruit has bee introduced into cultivation comparatively lately into the plai of India. Utkhuli, Michaelpatti, Vellodu and Penukonda i the Madras Presidency are the important pomegranate growi regions in South India, but in the Bombay Presidency this fru is cultivated in two important zones, namely, near about Dholl in the northern Gujerat and in Poona, Sholapur and Satara di tricts of the Deccan. There is a sprinkling of pomegrana plantations in other districts of this Presidency, which goes indicate the possibility of the extension of this easily grown fru crop. The total area under this crop in the Bombay Presiden is at present 2,000 acres (1937-38).

In the Presidency of Bombay, the pomegranate is cc

sidered as the poor man's crop owing to the inferior type of soil allotted to it and the neglect with which it is treated in orchards. The sites at the foot of hills or at the top of high lying areas, which retain little or no water and where other crops do not thrive, are usually set apart for the pomegranate. The pomegranate tolerates a soil which is limy or slightly alkaline. Of course, it thrives very well in better kinds of soil where it yields a heavier crop. It prefers a light deep loam.

Soil

The pomegranate succeeds well from the sea-level to an altitude of about 4,000 feet. In Cyprus (21), it is cultivated mainly along the sea-coast. For its successful cultivation, the pomegranate requires a semi-arid climate. In humid climates, the quality of the fruit is not very satisfactory, as, for instance, in Blackden Shore, Florida, Hawaii, West Coast of India, etc. Being a hardy plant, which can stand considerable amount of drought and poverty of soil as well as neglect in cultivation, the fruit has stuck on in India even under the apparently unfavourable climatic conditions.

Climate

In the Dholka region of north Gujerat, the scarcity of water limits the extension of pomegranate cultivation although the soil is loamy and the climate is encouraging to this crop. In the Deccan, the annual precipitation ranges from ten to twenty inches, and this occurs during a short period of about three months of the year. This is not normally supplemented with well or canal water in most pomegranate plantations. The pomegranate trees come into flush and bloom with the break of monsoon every year. The crop is harvested before the effect of the last shower is over. During the rest of the year, the trees are literally neglected. During the summer months, it is a common sight to see the trees standing out prominently with barren branches apparently looking as if they are dried up. With good irrigation pomegranate gets greatly benefited.

Irrigation

Because of its hardiness and ease of cultivation, the pomegranate is considered as an important money crop on poor soils of certain districts of the Deccan. It does not tax the cultivator in any way by requiring much money or labour to be spent on raising the crop. The income though small, is fairly steady.

Economic importance

The extension of pomegranate cultivation is, however, not going on rapidly as far as one would wish, because the quality of the fruit grown under ordinary conditions of soil and climate is not very high. The fruit cracks badly as a result of variations in the irrigation and other cultural methods, or possibly due to the environment. The possibilities and the best methods of preserving the fruit juice are not also yet fully worked out. These considerations limit the extensive cultivation of pomegranates. It is to be hoped that extension will be favoured by improved cultural methods, evolving of superior varieties and of suitable methods of manufacture of beverages.

Limiting factors

The pomegranates grown in the Presidency of Bombay may be divided into two varieties one with white flesh and soft seeds, grown at Dholka, and the other with deep pink flesh and hard seeds grown in the Deccan or known as Alandi or Vadki.

Varieties

(1) *Dholka types* :—Fruits of large size; flesh pinkish-white or whitish; seeds medium soft; juice sweet; colour of rind greenish white.

(2) *Alandi or Vadki* (Deccan). Fruits of medium size; flesh blood red or deep pink when the fruit is ripe; seeds very hard; juice sweet but slightly acidic.

An attempt was made in the Deccan to grow the Kabul variety of pomegranates some time ago without success. The plants were stunted in growth and bore fruit very poorly. The attempt has, therefore, been given up.

The following are some of the well-known foreign varieties:—

I. *Varieties from Baghdad and Palestine:*—

(1) *Selimi* from Baghdad: bears very big fruits weighing one kilogram; fruit is juicy and sweet.

(2) *Roman Chokab* (black pomegranate) is cultivated in Bagdad: fruit is dark coloured with large seeds. It has a tender sweet-sour taste.

(3) *Wellissi* from Palestine is considered to be the best as it is soft seeded and very early to bear.

(4) *Ras-el-Baghi* from Palestine, bears large, sweet and early fruits.

(5) *Suffami* from Palestine produces big juicy fruit with delicious sweet-sour taste. The best specimen o

this variety is obtained from Kabul, Afghanistan and Persia.

II. *Varieties from Spain:—*

(1) *Dulca Colorado.* Fruit big, sweet and tasty.

(2) *Granad Blanc.* Fruit seedless.

III. *Commercial varieties of California.*

(1) *Choodesuy.* Fruit of very high quality; stands transportation well.

(2) *Boomageny.* Fruits large, very juicy, and stands shipment well.

IV. Pomegranates in Cyprus are grouped into three distinct classes, *viz.* (21):—

(1) The sweet pomegranates locally known as *Glykia.*

(2) The sour pomegranates, neither sweet nor sour, but of a mild sourish taste, locally known as *Maifoshika*, and

(3) The sour pomegranate.

V. Indian pomegranates (excluding those of the north-west) are not reputed for quality. Most of the commercially cultivated varieties broadly fall under two groups—the white fleshed and the pink fleshed. The quality and size of fruits, however, vary greatly according to locality. The correct nomenclature and classification of the various indigenous types have not yet been attempted in this country.

An improved strain of pomegranates has been evolved at the Ganeshkhind Fruit Experiment Station, Kirkee, as a result of an attempt to select from the local Vadki or Alandi variety suited to the Deccan conditions of soil and climate. This is named Ganeshkhind No. 1. The fruits of this strain have very soft seeds with pinkish flesh and juice with an extremely agreeable flavour. This strain is under trial and has been vegetatively propagated by cutting. Certain other strains selected for their quality are also under observation.

The following foreign fruits are sold in Indian markets:—

1. *Muskati.* Fruit of medium size; rind russet green; seeds soft; flesh pinkish and sweet;
2. *Kandhari.* Fruit larger in size than *Muskati*; flesh deep red; seeds medium soft; colour of the rind deep red.

3. *Sour pomegrantes*, which generally grow wild in t forests of the Himalayan mountains are as a r not sold in the fresh condition, but are availa as a dried product for use as a condiment in pl of tamarind.

The common method of propagating pomegranate plants the Bombay Presidency is by raising seedlings. Seeds are tak from ripe fruits indiscriminately and sown seedbeds. When they are of sufficient heig they are directly planted in their permanent place in the plan tions. The inferior quality of fruits produced and the gene degeneration of the local types from time to time are larg attributable to this method of multiplying our planting sto In the Punjab and the North Western Frontier Province, pom granate plants are propagated by hard-wood cuttings. countries like Palestine and Afghanistan also, pomegran plants are propagated by using hardwood cuttings on a co mercial scale. The cuttings so used are generally ten to twel inches long and about a quarter to half-an-inch in diamet Cuttings of fairly mature wood are taken from suckers whi spring up from the base of the main stems, and planted eight ten inches apart in the row. Pomegranate can be propagat by *layering* also. But this method is rather more expensive. Cyprus (21), pomegranates are propagated either by cuttin or by suckers. These are planted either in their permane sites direct, or kept for one year in the nursery. In Java, t pomegranates are propagated by root suckers or marcottes (

Propagation

In the shallow and stony soils of the Deccan, pomegran plants are planted, twelve to fifteen feet apart. In lighter deeper soils, the distance is increased to eighte feet. At Vadki and Alandi, the spacing va from twelve to fifteen feet. Usually pits of two feet by two f by two feet are taken at the required distance and filled w about forty pounds farm yard manure mixed with fine soil. manure is, however, used in filling pits in some places. Se lings, which are twelve to fifteen inches in height, are then plan and watered immediately. Planting is usually done in the mo soon in the Deccan, while in Sind and Northern India, pomeg nate planting is done mainly in early spring. Some gaps m occur by the death of newly planted seedlings. These gaps h

Planting

to be filled up by fresh planting. When they are once established, the seedlings become hardy, and can stand a considerable amount of drought and such adverse conditions. As a commercial crop, pomegranate in Cyprus is planted at eight to ten feet each way. It is sometimes planted as a secondary or filler crop in young orange plantations too.

Although pomegranate plants can withstand a good amount of drought, they respond very well to adequate water supply.

Irrigation.

In order to get a good growth of trees and a bumper crop of fruits, proper irrigation is essential to the trees. In the Bombay Presidency the usual method of watering is by the bed or basin system. Small round basins are made at the base of each tree, and filled with irrigation water at each turn. As the spacing between the trees is limited, the whole orchard practically gets wet by irrigation and the system amounts to flooding. In order to economise irrigation water, trees are treated for the crop during the monsoon months and almost neglected during the rest of the year. Monsoon showers are supplemented by artificial irrigation only during the months of May and June. If rains fail, irrigation has to be given even during the monsoon months, when fruits are on the trees. Copious and regular irrigation is essential during fruiting season, as irregular moisture conditions in the soil at that period result in a large number of fruits cracking. Where the soil is light, the furrow method of irrigation may perhaps be found useful.

Well-rotten old farm yard manure mixed with household ashes is usually applied to pomegranate plants at the rate of forty

Manuring

pounds per seedling while planting. After this, three to six baskets of old cattle manure alone are given to each tree every year at the break of the monsoon or a little before the trees are treated for the crop. At Vadki, where no manure is given while planting, a couple of handfuls of cattle manure is given per plant about six months after planting. The annual dose of manure then follows at the usual rate mentioned above.

Where moisture in the soil is enough, the pomegranate plants produce a large number of suckers from the base of the

Suckering

main trunk, and form a bush. The suckers hinder the proper setting and development of fruits. They also utilise a large quantity of soil nutrients, that

should properly go to feed the main stem. They, therefore, gro at the cost of the main tree. The pomegranate plants shoul be encouraged to develop a clean main stem free from sucker A single clean main stem has several advantages. The tre makes a well balanced erect growth. Fruiting is facilitatec Cultural operations at the base of trees become easier. Lastl borers and other insect pests do not find suitable harbourin ground for attacking the stem later. Suckers should be prune off as soon as they appear. They will be few and far betwee when once the tree has formed a single clean main stem.

Pruning

Pomegranate trees do not usually require pruning except fo removing the suckers and giving a shape to the trees. Fruits ar borne on short terminal spurs, which have t be at least of two years of age. Popenoe (18 remarks that the wood of pomegranate plants bears for severa years, but as the years pass on, the stem loses its fruit bearin habit. New shoots take up this function, and thus the bearin of the tree continues. Little or no fruit is borne in the interio of the plants. It has been observed that heavy pruning of th branches reduces bearing of fruits for the following two or thre years at least. As a rule, no systematic pruning is practised o pomegranate trees in Bombay Presidency or elsewhere in India.

Parsons (17) recommends for Ceylon a pomegranate tree wit a round shaped head, and this is obtained by short-elongatec shoots and thinning out congested growth. Hodgson (11 has outlined a system of pruning in California in order to have suitable tree form. The method of pruning is simple. Th tree on planting, is cut back at twenty-four to thirty inches fror the ground. As the buds are produced they are thinned to thre to five scaffold branches. These too are cut down to make ther stocky. In the next pruning season, the scaffold branches ar shortened to three-fifths of their length. New buds arising o these branches should not exceed three in number. The tre should be free from sucker growth. The desired tree form i accomplished by the end of the second or third year.

According to seasonal changes in the atmosphere, there ar three flowering seasons a year in the Deccan for pomegranat also (12). The *Mrig bahar* synchronises with the break monsoon in the Deccan, and it is usually taken advantage o It is always desirable to attempt only one of the three season

annually in order to get a regular crop of well developed good fruits. Pomegranate plants come to regular bearing in their fourth or fifth year. Fruits ripen in six to seven months from flowering. After the rains, that is, in October-November, the trees shed their leaves and at that time the land is ploughed or dug up. The roots of trees are exposed by digging out the soil from the basin to a depth of about six inches, for ten to fifteen days. Fibrous roots which are kept exposed are all pruned neatly and all injury caused to the thicker roots in the course of the operation is treated with coal tar to prevent infection from soil organisms and to expedite healing. The usual dose of manure is then spread on the soil taken out of the base of the trees, and this is replaced after mixing it with manure. The water channels and beds are made, and irrigation follows. These operations continue till about the middle of February, when the first irrigation is given, though sparingly. Watering is gradually increased to normal quantity in the third turn after which this supply is maintained at regular intervals. Flowers appear in about a month from first watering. When the fruits have set, the soil at the foot of the trees is stirred at least once a month. These are the treatments of *Ambe bahar*. In the case of *Mrig bahar*, the trees are treated in April, exactly in the same way as for *Ambe bahar*. The first watering is given about the beginning of May (*Aksha Tritiya*) and the fruits are harvested about six months after. It is generally not possible to treat trees for *Hatti bahar* or the September flowering, because the trees cannot get any rest from active growth during the rainy months which precede. However, when there is a long break in the rains during August-September, and when neither of the other flowering seasons is successfully treated for, the *Hatti bahar* also may be attempted.

Treating the trees for crops

Although due to the mild nature of the Deccan climate, the pomegranate trees may be induced to bear fruit at any one of the seasons described above, the usual cropping season is the *Mrig bahar*, and the fruits ripen in the months of October, November and December. Some growers prefer to have the fruits ripen in the summer months to get market advantage by taking *Ambe bahar*. Pomegranate fruits can, therefore, be had in

Season of harvesting and yield

the Bombay Presidency almost throughout the year. But th right quality of fruit is available only during the winter month which form the natural cropping season. On an averag pomegranate trees of about ten years of age may bear 100—20 fruits each per annum. Fruits grown in the Bombay Presidenc are, of course, inferior in quality to those of Afghanistan an Persia. In Cyprus, the average production is estimated at 250 to 3000 okes (1 oke=2·75 lb.) per statute donum (14).

Improvement of pomegranate by selection

As mentioned elsewhere, effort has been made to improv the quality of the Deccan pomegranates. The local type ha very hard seeds and little pulp, with slightl acid juice. Its continued propagation by see through several generations has contribute to its degeneration very considerably. Im provement was, therefore, taken up by individual tree selectio at the Modibag, Poona, and the Ganeshkhind Fruit Experi ment Station, Kirkee, where individual performance recor was maintained in the case of a large number of seedling tree for many years, and selection was made of those which ha soft seeds, better pulp and sweet juice. Trees so selected hav been further propagated vegetatively, and the progeny raise by cuttings is found to possess all the good points of the selecte parent. Ganeshkhind No. 1, is found to be an exceptionall superior strain. This is being further propagated for distribu tion. It is suggested that for substantial improvement of thi crop, selection of superior trees should be made in all localitie which grow pomegranate and the trees marked out for thei high quality of fruits should be further propagated vegetatively New plantations should be raised only with plants taken vege tatively from such selected trees. Seedling plantations shoul become things of the past. Or else, the quality of Deccan pome granates will remain low, and it might further deteriorate.

Fruit cracking

Pomegranate fruits are notorious for their crackin habit. It is a serious trouble in the Deccan. Damage du to cracking is enormous, reaching even up t 50 per cent. of the total crop. It is difficul to attribute cracking of the fruits to any definite causes, as n regular experiments have been carried out on this problem a yet. It is supposed to be due to unequal moisture contents a the roots. It is not known if cracking of fruits is associated wit

any causal organism. But, it is no wonder if spoilage due to organisms follows cracking and exposure of the inner pulp. It is suggested that regular irrigation and interculture throughout the bearing age may remedy cracking. The Cyprus pomegranate growers are of the opinion that irregularity in watering and lack of moisture at the roots are responsible for bursting of fruits, which consequently become unmarketable (21).

Harvesting

Pomegranates are a rare type of fruit which keep well for a long time after harvesting. The fruits are harvested when the rind attains the proper colour—yellowish brown in the Deccan type. But often this is not a sure guide to pick fruits. Experienced growers pick fruits when they give a distinct sound of grains cracking inside when slightly pressed from outside. This is tried in a few cases, and all fruits which are approximately of that maturity are picked. Owing to the cracking of fruits, promegranates are often harvested when they are still immature. This tells on the quality of the marketed fruit under the Deccan conditions. Fruits are picked at intervals of a week each, commencing from about the first week of October. As the fruits are firmly attached by strong stalks to the main wood of the tree, it is better to clip them rather than to pull them, while harvesting. Some writers recommend the harvesting of the fruits before they are fully ripe, as this would, in their opinion, minimise cracking.

In a cool and dry place, the fruits keep well for several months. Though the rind loses its striking lustre and shrinks, the quality and flavour of fruits improve by long keeping. It is reported by Hodgson (11) that the fruits improve in quality and ripeness, when stored in cold storage, where they keep well in excellent condition for about six months. The rind shrinks and becomes thinner and tougher. The amount of rag decreases and the seed coat grows more tender and edible.

Packing

"In Spain (13) fruits are packed in wooden boxes similar to those used in packing sweet limes. The standard packing quality depends upon the price offered per case of fruits in foreign countries. In California fruits after harvest are sent to the packing house, where they are wiped clean of all dirt. They are then sized, the sizes running from 24 to 110 per box. After sizing, the fruits are wrapped in tissue

paper. The commercial package is the orange half-box mad six pieces, two each for the top and bottom, and one for e side. With fruits, the package, when ready, weighs about 3 40 lb." In the Deccan, pomegranates are packed in bam baskets without proper sizing or grading. The baskets c tain fifty to seventy-five fruits each.

The pomegranate baskets are carted in bullock carts to Poona and other city markets. The carts are loaded with layers of such baskets.

A good deal of business is carried on in pomegranate rind a dyeing material both locally in Cyprus and for export. I estimated that over 30,000 okes (14) are in use in the local cl dyeing industry. The export in rind is mainly confined to Eg and Greece, which in 1929, amounted to 57,435 okes valued £479. All the parts of the pomegranate plants are used in form or other. Pomegranate juice contains citric acid. Its su content is more than that in apricots a peaches. In the Balkan peninsula, a kind wine is prepared from pomegranate juice and this wine is c sidered superior to grape wine. Pomegranate juice is used so times against leprosy.

Uses of pomegranate

"The pomegranate fruit is known for its medicinal propert The bark and rind are recognised astringents employed in the peutics in dysentry and diarrhoea. The rind when boiled for many generations past been the remedy for tenia. A black smooth writing ink is also made out of it. A cooling dr known as "grenadine" is also made of the pulp by adding wa and sugar for use in fevers. The bark of the stem and root used for slimming purposes.

"The fruit is very refreshing and hence is eaten fresh in countries. The sweet type is said to be a mild laxative. intermediate type between sweet and sour is reputed to be g on the inflammation of the stomach and for heart pain. pomegranate fruit is highly commended for its delicacy possessing flavours like the apple. The plant is highly val for its decorative effect in the United States of America. W effort it can be trained into trellis to divide portions of the sa garden with considerable effect. The tree is also grown a hedge or wind break on sandy slopes."

Fresh juice of pomegranates retains its flavour and k

Pomegranate juice

well when bottled after sweetening with sugar. The grains of pomegranate are first collected after removing the skin and other portions of the fruit. They are then crushed in the meat-mincer and the juice squeezed through a thick cloth or in a basket type wooden press. The pomace is mixed with one fourth its quantity of water and heated a little (160—165°F) to extract the colour. The extract is again squeezed through a thick cloth and the two extracts are mixed. Half this quantity of sugar is added and the sweetened juice is preserved (after regulating the acidity to 1·5—2% with citric acid) with 0·1 per cent. sodium benzoate in air tight sterilized bottles which are then stored in a cool dry place. Siddappa (19) also produced bottled sweetened juice by heating it to 175 to 184°F, cooling it quickly and after allowing it to stand overnight, decanting or filtering it. The filled bottles have to be pasteurized at 175—180°F. for 30 minutes. In one good variety the juice was 40·1% of the entire fruit and total solids varied from 17·3 to 18·5% of the juice, acids running from 0·81 to 1·23% as citric acid.

Fruit borer

The pomegranate fruit is attacked by *Virochola isocrates* Fb. a small caterpillar locally known as *sursa*. The butterfly lays white eggs on flowers or small fruits. The eggs hatch out into caterpillars which bore into fruits and buds, and feed specially on seeds, till these are full-grown. The attacked fruit appears sound outwardly but is severely damaged inside. The full-grown caterpillar comes out of the fruit and ties its stalk to the main branch with its fine web to ensure against its falling and pupates inside the fruit. By way of control, infested fruits should be removed and burnt or buried. Covering the unaffected fruit buds and small fruits with small paper or cloth bags is very effective. It was found that 92% of the fruits bagged in this manner yielded very good fruits on full maturity, whereas only 47% of unbagged fruits escaped the attack of the caterpillar. Paper bags can last for two or three seasons, if used carefully, thus economising the cost of bagging. Bagging is, however, economical only when fruits are of a high quality.

Chikta is caused by small white insects *Aleurodes* sp. found in large numbers on the lower surface of leaves. They secrete copious amount of honey-dew on which black mould may

develop. The damage is done by removing the sap sucking as well as interfering in the photosynthesis whi

Chikta

results in malformation of fruits. The pest controlled by spraying with rosin compou prepared with the following formula:—

Rosin	5 lb.	Powder rosin and mix it w soda in a vessel and a
Washing Soda	1 lb.	enough water. Boil t mixture and keep on addin
Water	5 gals.	little of water till the mater is clear and coffee coloure

When ripe, it should not give a milky appearance, when a dr of water is added to it. This stock solution should be furth diluted for spraying in the ratio of 1 : 6.

In old and neglected gardens particularly, the main trun of trees will be found badly infested with stem borer cat

Stem borer

pillars (*Arbella* sp.). Wherever the caterpill is eating inside, a small hole will be seen a the network of the dried excreta of the insect will be fou outside the hole. This has to be cleared and the insect should extracted by inserting a fine hooked wire into the hole. If t is not possible, a small cotton plug dipped in petrol, chlorofor or kerosene oil may be inserted and the hole closed with mu The insect inside will die of suffocation caused by the vapour the chemical. Considerable damage to plantations is caused this stem borer. All the bark and other portion eaten by it shou be cleaned and the damaged parts treated by coal tar to enal the wound to heal up.

Fruit rot is at present the only known trouble caused fungus in the case of pomegranates in the Bombay Presiden

Fruit rot

The fruits rot badly, partially or wholly a become useless. The only remedy is to remo all affected fruits and burn them. The fruits may be spray with Bordeaux mixture (5: 5: 50) as a preventive remedy.

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CHAPTER VI

PAPAYA (*Carica papaya* L.)

Papaya is an exotic plant in Western India, having been introduced into this tract comparatively recently. It has since gained considerable commercial importance. It is second to banana in regard to yield of fruits and money income in the districts of Poona and Nasik, and other tracts surrounding large city markets. It is also grown widely in Gujerat. Its cultivation is easy, it gives quick returns and adapts itself to diverse soil and climatic conditions. Papaya is also gaining popular favour as a table fruit all over this country. The importance of evolving and growing superior types of papaya cannot be over-estimated, especially in view of its commercial significance and the possible future developments. But as in the case of all other fruits in India, papaya has not so far attracted the attention of plant breeders in this country.

Introduction

Tropical America is believed to be the home of papaya. The plant is now widely distributed, being grown on a large scale in India, Ceylon and Malaya Archipelago, in Hawaii, and in Australia as far as Sydney. In the United States of America the cultivation of papaya is restricted to Florida and California. Its distribution in the Bombay Presidency is mainly restricted to the Deccan and Gujerat Divisions. The districts of Ahmedabad, Broach and East Khandesh grow papaya to some extent. In the year 1925-26, the total area under papaya in the Presidency was a little over 500 acres, while it stood at 1,856 in 1933-34 and at 927 acres in 1937-38. The area in Bihar is 9,700 acres, in U. P. 1672 acres and in Assam 10,000 acres. In the Baroda State and Kathiawar, the cultivation of papaya is extending recently by leaps and bounds, the Honey-dew "variety" gaining much popularity in new plantations. In South India also this fruit thrives, but it is not very popular owing to

Origin and distribution

some prejudice against it in the public mind, particularly i Tamilnad.

Papaya belongs to the family *Caricaceae*. This fruit is know by different names in different countries of the world. Papay apaya, papaja, papaw, and tree melon are some of the more com mon terms used, although the term papaya is the most wide adopted one. The name "Papaw" which applies to *Asimi triloba*, Dunal, a tree native to the United States of Americ is also sometimes wrongly used to designate papaya. To avoi confusion it seems most necessary that the word papaya b used as the only correct name for the *Carica papaya*. Apart fro the cultivated types, there are several species of the genus *Caric* which are grown extensively in different parts of the tropic such as, *Carica Candamarcensis*, *C. erythrocarpa*, *C. quercifoli*. *C papaya*, however, is the only useful species under cultivatio Being chiefly a diœcious plant, cross-breeding is the rule i papaya. It is further propagated mainly by seeds. This prac tice gives rise to innumerable variations in tree and fruit charac ters. It has, therefore, been extremely difficult to classify th known types of papaya, and to keep them pure for any length c time. Similarly, it has been difficult to fix up any standar nomenclature of known varieties in its case. The names c so-called varieties or types are derived largely from the place where they were originally recognised, and there exists a goo deal of confusion as to the distinctive characters of thes varieties.

Varieties

Carica papaya includes a large number of horticultural type such as the Australia, the Blue Java, the Madgascar, the Ne Zealand, the Gujerat, the Ranchi, the Wa shington, the Honey-dew, the Bangalore, th Singapore, etc. But the Gujerat, the Washington and the Hone dew are the only types which are favoured in Western Indi The following is a brief description of these:—

1. The Washington papaya:—Tree is fairly dwarf; ste has purple rings at the nodes; petiole dark purpl growing darker towards the lamina; flowers dee yellow; fruits borne in large numbers, large an ovate; pulp sweet and flavour agreeable; seed few; fruit keeps better than the other types grow in the Presidency. The flesh is free from the d

SINGAPORE PAPAYA TREE WITH FRUITS.

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agreeable smell and slightly bitter taste which are characteristic of the local Gujerat type and, therefore, makes this fruit very popular.

2. The Honey-dew:—Tree of medium height; bears fruits low on the trunk and heavily; flowers resemble those of the Gujerat type; fruit elongated and the pulp is extra fine, sweet and has very agreeable flavour; seeds not many. This type is lately extending in cultivation in Gujerat and Kathiawar areas. It is locally named *Madhu-Bindu*.

3. The Gujerat:—This type has trees of medium height and bears very heavily. It differs from the Washington in having green or yellowish green petiole, leaves and stem; flowers white; fruits are bigger and longer than those of the Washington. Seeds are many. Fruit is fairly sweet, but has a slightly objectionable flavour and is somewhat bitter.

Due to propagation by seeds there are a large number of variations in each so-called variety, and, therefore, there is a good deal of confusion in the correct identification of the types. All papaya types are diœcious but hermaphrodite trees in the same type are not, however, uncommon.

Soil

Since the papaya tree is evergreen and bears flowers and fruits for the most part of the year almost continuously once it comes to bearing, it prefers a rich and well-drained soil. It may grow on a poor soil with heavy manuring and watering, such as in the laterite soils of this Presidency. Soils with murum at about two or three feet below the surface are congenial to papaya trees. They do not thrive in deep clayey soils as may be observed in the Khandesh, Nasik and Poona districts. Trees grown on poor limy soils give few and small fruits. On loamy soils, the papaya trees make good growth. A thorough drainage is absolutely necessary for the good health of the trees, as otherwise they suffer much from stagnation of water. The unhealthy condition of trees brought about by water-logging or over-irrigation is recognised by the foliage turning yellow and by the dropping of the lower leaves prematurely. It is very necessary that papaya plantations are thoroughly drained in the Konkan area where rainfall is heavy. It is observed in the district of

Poona that whenever there is heavy rain, which might floo the papaya orchards, trees suffer from collar rot caused by moisture-loving fungus *Pythium aphanidermatum*. Young plan are more susceptible to this disease than older ones. It essential that the field should be perfectly levelled and wel drained to avoid such diseases. This precaution also holds goo for orchards which are irrigated by canal water.

Climate

Papaya grows luxuriantly in all tropical climates. Th chief limiting factor for its growth and fruiting appears to b the occurrence of low temperature and fros If the atmospheric temperature falls to abo 35°F, it does considerable damage to the growth of papaya tree Very often a strong wind coupled with low temperature destro the whole crop. Lack of sufficient warmth in the atmosphe always retards maturing and ripening of the fruits. A dry war climate tends to add to the sweetness of the fruits. Excessiv moisture affects the quality of fruits adversely. It is due to the reasons that papaya fruits grown in the dry districts of th Deccan are priced more in the Bombay market. The papay stem is sensitive to strong winds and is, therefore, required to b protected from exposure to them, lest the trees break dow In high lying areas where the trees are exposed to strong winc or storms, suitable windbreaks are essential to protect the tree Such windbreaks also save the trees to a great extent fro damage caused by cold winds or when frosts occur.

Propagation

The most common method of propagation of papaya is fro seeds. For this purpose, well-matured, large fruits borne o female plants are collected and preserved i a safe place until they are properly rip They are then cut open, and the seeds are carefully extracte on trays. They are washed and dried in the sun or shade a are stored in bottles or in clean tins till they are required f sowing. Fresh seeds may, on washing, be mixed with fine co wood ash which absorbs the slimy coating on them, and helps keep the seeds separate on drying. The seeds retain vitality f several years if carefully preserved from insect attack, althou it would seem that this fact is not true in all papayas and in a places.

The best time for raising papaya seedlings in the Bombay Pr sidency is the monsoon, that is, from about the middle of June

the end of October or November. Sowing afterwards will not give satisfactory germination due to cold. The moist warm weather of the monsoon favours rapid germination of seeds. If seedlings have to be raised on a commercial scale, they are grown in beds on the ground. The site selected for seedbeds is dug or ploughed and then made friable by keeping it fallow for some time. On making it perfectly level, raised beds of convenient size, roughly six feet by three feet, are made six inches above the general ground level. Over them a layer of river soil three inches deep mixed with half the quantity of leaf mould and farmyard manure is spread and the surface is made perfectly level. Papaya seeds are sown half-an-inch deep and an inch apart, in rows six inches apart, and watered gently with a can having a fine "rose". If there be any likelihood of heavy rains or excessive sunlight, the seedbeds should be protected with thatches. The seeds take about three weeks for germination, which may be hastened by moist heat. After about two months more, when the seedlings attain a height of nine inches to one foot, they are transplanted in their permanent places. Planting is done at eight feet distance each way and the number of pits is nearly 700—800 per acre. Two or three seedlings are generally planted in each pit in the Deccan, and therefore an acre of land will accommodate 1400—2400 seedlings. In Gujerat and Kathiawar regions, the spacing in papaya is 10 feet, and there will be only 400—500 pits and about 800 to 1500 seedlings in an acre. Seedlings raised in beds on the ground do not stand transport for more than about two days. It seems, therefore, better to raise them in flat boxes. While taking the seedlings out of beds for planting, much damage is usually caused by injury to the roots. It is obviously safer to transplant seedlings raised in boxes than those raised in the ground. A suitable size of the sowing box is 2 ft. by $1\frac{1}{2}$ ft. by 9 inches. It was found in the Madras Presidency that during the rainy season, when the weather is very humid, papaya seedlings stood transplanting even with their roots naked, provided the tap roots were not severely injured and that the transplanting was done on a cool day, preferably in the afternoons, and also a partial defoliation was done at the time of lifting them from the beds. Transplanting under such weather conditions is specially successful if the seedlings have been raised in pots or boxes. An attempt was made at the Ganeshkhind Fruit Experiment Sta-

tion, Kirkee, to find out the difference made by transplanti papaya seedlings from seedbeds, and sowing seeds direct in t permanent places in the field. It was observed that the form method was much more economical, and contributed to a bett stand in the field in the long run. The reason for this is that t seeds do not always germinate properly in the field and t tender seedlings die away in their earlier stages of growth und the exposed field conditions.

Vegetative methods of propagation

The papaya plant can also be propagated from cuttings a grafts. Propagation from seeds is, however, preferred, becau the vegetative methods of propagation a not economical. If pure lines of diœcio types of papaya are developed, the ne for vegetative propagation will not arise in this fruit. It reported that grafted plants do not also make vigorous growt The growers have returned back to seed propagation. In t Philippine Islands, a method of propagation of papaya plan by root cuttings has been evolved. Roots of medium size from full grown tree are selected, and cuttings of the length of 10- cms. are planted in nursery beds made of sand. These cuttin are kept moist and in about four weeks, the adventitious bu develop and the cuttings grow into vigorous plants. A number workers in India have successfully, raised papaya plants fro cuttings. The rooted cuttings are seen to thrive properly, whe small branches are taken with a heel from the parent tree. Cu tings made of very old or very immature parts of the plant ro in the bed and do not sprout readily. Papaya can be graft with success when the operation is carefully done. According Higgins and Holt (18), an attempt was made by Rolf to prop gate papaya by enarch grafts. Later, cleft grafting was adopte with success and it consisted of inserting scions from shoots two-month-old seedlings. The rootstock is headed off at a su able height, and then the cleft is made to receive the scion. Th method brought about early bearing. At Sabour (Bihar), a nu ber of papaya plants were raised during 1934-35 by cleft graftin and these were later reported to have borne crop earlier th seedling trees of the same age. In Java and elsewhere (14), si grafting in the dry season is successfully employed. Tachdjian(3 considers that papaya seedlings should be 20-30 cms. high the time of grafting, and these when grafted, fruit in eight mont

Preparatory tillage

For raising a papaya plantation, the site is ploughed and harrowed ordinarily in the summer, as many times as possible, until a good tilth is obtained. Then it is levelled and pits of the dimensions $1\frac{1}{2}$ feet by $1\frac{1}{2}$ feet by $1\frac{1}{2}$ feet are taken in most places, eight feet apart each way. The size of the pits may vary according to the nature of the soil, deeper clayey soils requiring larger pits than loamy soils. The surface soil is usually thrown on one side of the pit and the subsoil on the other as in the case of other fruit tree plantings. Pits are left exposed for a few days for weathering. They are then filled with surface soil, mixed with well rotten farmyard manure at the rate of 40-50 lb. per pit. Some also apply old bone meal at the rate of three pounds per pit. The pits are then marked with small sticks, and left over till the planting season. At the advent of the first monsoon, it is a good practice to sow sann hemp (*Crotolaria juncea*) for green manuring the soil during the season prior to planting papaya.

Spacing

In order to determine the proper spacing required by papaya trees, plants were planted in a trial at Poona at varying distances from two feet to eight feet each way from plant to plant. It was observed that papaya plants thrived best when the distance of eight feet was given to them. It was also noticed that the thickness of the stem was directly proportional to the spacing. Ten feet spacing is adopted in Northern and Southern India by many growers while others adopt even 5-6 feet. This distance facilitates inter-cultivation. The Ceylon practice is to space plants at twelve feet each way. In Florida the planting distances vary from six feet to ten by ten feet with different types.

Planting

Papaya plantations are raised in the Bombay Presidency in two ways, namely, by sowing a few seeds *in situ* where the trees are required, and by transplanting seedlings from seedbeds. In the first method, a few seeds are sown in the basin direct, where plants are desired to be raised in the field. This practice prevails in Khandesh districts. After the seeds germinate, the extra seedlings are removed, retaining only two or three vigorous ones. In the second method, seedlings are raised in seedbeds and transplanted in the field. Raising of seedlings *in situ*, as explained already is a more expensive method. It is observed that self-sown papaya trees take a

longer time for flowering and the fruits borne on them are sma
in size than those on transplanted trees.

Irrigation

The papaya tree responds readily to copious watering
well-drained soils. Though a succulent tree, the papaya d
not demand as much water as the bana
Regular and judicious irrigation influen
the proper development of fruits favourably and induces
tree to bear larger and more fruits. In the Deccan, papa
trees are irrigated once in eight to ten days in winter, or
in six days in summer, and occasionally as required during
break of rains during the monsoon months. The quantity
water given depends upon the nature of the soil, but filli
basins well is the usual practice. In the alluvial soils of Guje
more frequent watering is needed for papaya trees than in t
heavier soils of the Deccan. In the course of experiments carri
out at the Ganeshkhind Fruit Experiment Station, Kirkee, it w
noticed that the ring system of irrigation is more advantageo
than square beds, as the former holds comparatively less wat
The square beds perhaps hold more water than the trees rea
need. It seems advisable to adopt either the ring or t
sloping basin system of irrigation in the case of papaya
this system prevents irrigation water from coming into dire
contact with the stem, thus preventing the incidence
collar rot. In adjusting the water requirements of papa
trees, care has to be exercised to see that no water-loggi
occurs at the roots. In Ceylon, and in the West Coast of Sou
India artificial irrigation is found usually unnecessary f
papaya trees, owing to the good distribution of rains over
large part of the year. This fact makes papaya cultivati
in those parts very cheap.

Manuring

The papaya tree is considered a heavy feeder and requi
plentiful manuring in one form or other, as the tree bears heav
and throughout the year. Farmyard manu
sheep dung, wood ash, bone meal or bo
ash, and oil cake are all used for papaya with success in differe
districts of the Bombay Presidency. In the Deccan about for
pounds of farmyard manure is usually applied to each pit wh
planting seedlings. A second dose of manure at the rate of 80
100 lb. of farmyard manure is given to each bed about fo
or five months after transplanting, just about the time of flow

BEAN CREEPER TRAINED ON PAPAYA TREE AS AN INTER-CROP.

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ing. The third dose of about the same quantity as the second is applied when the trees are about a year old, preferably at the commencement of rains. Round about cities like Bombay and Poona, where papaya fruits find a good and ready market, bone meal or bone ash is also applied in September after the heavy monsoon showers subside. In the district of Nasik (10) cowdung or wood ash or both are chiefly used for this crop once a year. Near Ahmedabad, Pattan and Poona excellent papaya fruits, big in size and sweet in taste are produced on effluent water. In Sind sheep dung or wood ash or both are used for the trees twice a year. Amongst the best fertilisers for papaya are also found to be decaying vegetable or animal matter and house sweepings. Barnett (4) suggests that a mixture of three parts by weight of superphosphate, one part of sulphate of ammonia and one and a half part of sulphate of potash will promote growth of trees as well as improve the quality of fruits, if the mixture is applied at the rate of two pounds per tree. Sulphate of potash if doubled in quantity may possibly enhance the keeping quality of fruits. Farmyard manure is undoubtedly one of the best manures for the crop. Pope (25) states that the application of farmyard manure to the soil is beneficial in papaya cultivation and adds that good results have followed the addition of complete chemical fertilisers of the following composition:

	lb.
Superphosphate	800
Sulphate of potash ..	315
Nitrate of soda	250
Sulphate of ammonia ..	190
Black volcanic sand ..	445

One pound of this mixture was worked round the stem of young papaya plants twice in the first year at intervals of six months each. Later, as the plants grew larger, applications of two pounds each were made.

When papaya is grown as the main crop, low growing vegetables of short duration such as chillies (*Capsicum* sp.), onions, cabbage, knolkohl and tomatoes may be grown as inter-crops for about six months from planting of papaya seedlings. After the plants grow bigger and shade

Inter-crops

the area, it is not possible to grow any inter-crop of the type men- tioned above profitably. But it is now experienced that papay trees when they are a year or more of age, and when they hav grown fairly tall with bare stems below the fruiting region, ca be well utilised as supports for creepers of beans. The beans ar planted round the stem of trees in the ground at the rate of four c five seeds in each bed. When they germinate and begin t grow, the creepers are trained to climb the papaya stem up t the fruiting region and not higher. All attempts of the creeper to disturb the fruiting region of the trees is checked by keepin the growing tops clipped at the proper height. The creeper do not suffer from the shade of the papaya trees, and yield a additional income without much extra cost or trouble. Thes beans should not be grown in the earlier stages of the papay plantation as they are fast growers and might unduly distur the main crop. Small and large plantations of papaya alike ma yield a good income per tree from the beans alone, which ar used as vegetables.

The papaya tree itself is often grown as an inter-crop i plantations of other fruit trees, where the spacing require for the main crop is more than fifteen feet. One or tw rows of papaya planted in the interspace of the main cro yield a very considerable profit during the short period of thre or four years, when papaya trees complete their economic lif cycle, without disturbing the main crop like citrus, mang sapota, and guava, which take a much longer time to come t bearing and would require to have the whole area left to them selves, after that.

If papaya plants are planted about ten feet apart each way the cultural operations in the plantations can be carried out b bullock power. Two ploughings and tw harrowings cross-wise are necessary in suc plantations every year. Only the space left unploughed nea the trees may be hand dug. After manuring, beds and wate channels are prepared. Besides, occasional stirring and weedin of the beds of the trees have to be done. Where papaya raised under irrigation, beds and channels may all be remove before the monsoon breaks, by ploughing the area, and th whole ground left practically levelled. If it be a ver heavy rainfall tract, then suitable trenches should be opene

Interculture

out in between the rows of trees, in order to drain out excess of rain water. In lighter soils it is necessary to raise a small nound of earth at the base of the trunk of papaya trees in order to support them from falling due to strong wind, or when the soil is soft due to irrigation. Since papaya is a shallow rooted plant, no weeds should be allowed to grow underneath it. It is not very desirable to plough the area very deep for the same reason. Frequent light cultivation and stirring the soil in the beds serve to increase the quality and quantity of the fruit crop.

Pruning of papaya

In Ceylon, planters prune the top of papaya seedlings, when they are about five months old in the plantation. This practice encourages side shoots which are said to produce a higher yield. A large majority of nale trees found in the plantation are also cut down about the ame time. There is also a conception that if such male trees are eaded off and left to produce branches, they change their sex and produce fruits later on. This conception does not appear o be well-founded and was actually proved wrong in a trial with a large number of trees at Kodur (Madras). Change of sex n papaya trees might occur occasionally in some trees, but uch changes are not certain.

Development of fruits

In about five months from transplanting the seedlings, flowers begin to appear and fruits set. The fruits take another six months to ripen. Thus, ripe fruits may be harvested in about a year from the time the seedlings are set out in the plantations. From his time, flowers appear continuously and fruits set and mature ithout a break for about nine to twelve months. Although apaya trees may bear flowers and fruits longer than this, fruits hich develop later on become small and the bearing is not nsidered economic after the trees are about two and a half ears old. In the Deccan, it invariably happens that there is ttle ripe fruit of papaya available in the market from July till bout the end of October. This shows that in winter on ccount of cold, the trees do not produce flowers and if at all ey do, the flowers do not set fruits. This state of affairs appens from December to the beginning of March. Naturally, erefore, a gap in the harvest is caused during the months of ugust and September. It is reported that in Hawaii (18), the

quality and flavour of papayas depend partially on the seas and the amount of rainfall.

In the diœcious pistillate or the pure femal eplant of papay flowers are commonly borne on short peduncles in the axil each leaf. The number of flowers on each peduncle varies fr three to four. Normally the terminal flower which is the olde

Thinning of fruits

develops into a fruit. As this fruit develo vigorously, the other branch flowers a automatically superseded. As a general rule, only one fr develops into normal size in the axil of a leaf. Sometim other flowers also develop into fruits and crowding takes pla which becomes intense as the plant grows older. In old trees, t internodal space decreases and consequently there sets in a co petition between the developing fruits, which cannot grow in large normal size. In order to allow only a limited nu ber of fruits to develop properly, so that they attain good size, thinning becomes an essential operation at t stage. Thinning is easily and quickly performed with a kni when the fruits are still young. Experiments on thinni of papaya fruits were carried out at the Ganeshkhind Fr Experiment Station, Kirkee, in the year 1910 (20). was observed in these trials that, though the individu fruits increased in weight in the case of plants where thi ning was practised, the total yield obtained from them was n enough to warrant the reduction of the number. The difficul is to hit on exactly the proper number of fruits to be thinn out, to get the highest weight compatible with the small number of fruits retained. This result can only be obtained practice. It may, therefore, be recommended that only su fruits may be removed as are expected to go bad, or to be fla tened and remain undeveloped by being pressed in betwe normally developed ones. Experimental data on this qu tion are not sufficient.

Observations recorded by some writers (9) show that a we formed papaya fruit containing no seed is not of uncomm

Seedlessness in papaya

occurrence. During the months of Augu 1923, to February, 1924, there appeared the Ganeshkhind Gardens orchard, seedl fruits on eleven female trees in the following numbers :—

Month.			Total number of fruits harvested.	Number of fruits found seedless.
1923.				
August ..	..	..	14	Nil
September	..	..	40	Nil
October	..	..	26	4
November	..	..	21	8
December	..	..	9	7
1924.				
January ..	..	..	18	9
February	..	..	14	11
	Total	..	142	39

his raised the question whether this lack of seeds was due to ck of pollination or lack of fertilisation. To solve this, owers on pure female trees were enclosed with paper envelopes cloth bags. In every case a bagged flower yielded a fruit ontaining no seed, but smaller in size than fruits developing eds in the usual way.

In the Punjab, on the Montgomery Fruit Farm, female apaya trees yielded seedless but otherwise normal fruits when ft open to natural conditions. No male papaya tree was, owever, found within a radius of several miles and evidently llination could not have taken place.

Partial pollination results in partial setting of seeds, the car-is corresponding to pollinated branches of the stigma alone set-ig seeds. On one and the same tree, fruits having seeds all er the pulp area and fruits with seeds at the stigmatic end ly, as well as those that are absolutely seedless are often found.

In the course of investigations on papaya at the Hawaiian gricultural Experiment Station, a papaya tree was found aring seedless fruits (17). In order to throw some light on the uses responsible for this occurrence, a few flowers on this tree ere hand pollinated, while others were closed in paraffin paper gs to prevent pollination by natural means. Some flowers

that were enclosed and unpollinated failed to produce fruits, pistils falling off within a week, while some others produ seedless and small-sized fruits. It is, therefore, inferred that p lination is not always necessary for the setting and developm of fruits and seedlessness may occur even when flowers exposed to pollination and have the same opportunities to fertilised as those on the surrounding trees, which produ normal fruits containing seeds. Possibly in the former case, pollination is ineffective due to some defect in the stigma or ovary or some other cause. Some investigators believe that se less papaya fruits are insipid in taste. Usually such fruits small and the layer of pulp in them is thinner than in seeded fru It is, therefore, not advisable according to them, to encourage development of seedless fruits on the trees. This may be tr under certain climatic conditions, but seedless fruits develop under the Poona, Sabour and Kodur conditions were not insip They are on an average undoubtedly smaller in size than seed fruits, but are equally good in taste.

Limiting factors

The extension of papaya cultivation depends upon, besi the availability of irrigation and not too low temperatures the evolution of desirable types which will retain their chara ters in successive generations, and whi will have a large proportion of bearing tre more pulp, better colour and high commercial storage value the fruits. If these characters can be combined in a type, cultivation of papaya can be enormously extended in t country. The extension of papaya cultivation is further h dered by a lack of proper marketing, transport and stora facilities suited to this highly perishable fruit. The preservati of surplus fruits in seasons of heavy harvest and manufacture papaya products are also essential in order to encourage furt cultivation. There is also an unfounded but extensively h belief in parts of South India that papaya fruit is not a desira food and causes particularly some serious ailments in wom A ripe papaya fruit eaten in moderation is one of the most heal ful of foods to all classes of people of both sexes and it is a p that the erroneous impression now prevalent among cert people should hinder the extension of area under this valua fruit.

In the case of papaya, the problem of sex is v

omplicated. Knowledge and study of papaya flowers, therefore, become essential. The following classification of papaya plants according to their flowers (15) is recognised:—

Sex in papayas

1. *Diœcious pistillate*, with large sessile pistillate flowers in the leaf axil. This is the normal female plant.
2. *Diœcious staminate*, with long narrow tubular flowers arranged on long peduncles, hanging from axils of leaves. This is the normal male plant.
3. *Andromonœcious* with male and hermaphrodite flowers on long peduncles.
4. *Polygamous*. A. With male, female and hermaphrodite flowers on the same tree on long penduncles.

   B. With male, female and hermaphrodite flowers on the same tree, the hermaphrodite flowers being of two types, one with ten stamens and the other with five stamens. Fruits are long in shape.
5. *Staminate*. A. With staminate flowers on short peduncles directly in the axils of leaves.

   B. With many hermaphrodite flowers on long peduncles.

   C. With separate staminate and clusters of staminate flowers with hermaphrodite flowers. This type yields long fruits.
6. *Hermaphrodite*. A. Hermaphrodite flowers on long peduncles.

   B. Hermaphrodite flowers with few pistillate flowers.

   C. Hermaphrodite flowers with many pistillate flowers.

may be remembered that none of these types is fixed and it ems that the papaya is still in a plastic condition so r as its sex is concerned. The papaya plant is known to nange in the course of its life history from being staminate to ermaphrodite and then to pure pistillate. The change is graual. In the beginning the plant may have staminate flowers nly. After some time it may bear a few hermaphrodite flowers ong with a majority of staminates. Then the hermaphrodites ay predominate, until in the succeeding stage a few staminate

only may be seen together with a few pistillate and with a la majority of hermaphrodite flowers. In the next stage pistil flowers may predominate until the hermaphrodites totally appear. In South Africa (19) the distribution of male tree reported to be about equal to the others in the papaya plantati In an orchard at Poona consisting of 215 papaya trees, 33 cent of the trees were observed to be pure females, 5 per c pure males, and 62 per cent hermaphrodites. A much grea percentage of males has been observed in papaya plantation Bihar and Madras, so that the elimination of male trees has co to be recognised as a very important problem.

Changing the sex

In some parts of India, as also elsewhere, it is believed t there exists some relation between different systems of roots young seedlings in seed beds and their sex. suggestion has also been advanced that i possible to detect the sex in papayas by the use of a metal in cator, while some others have said that sex could be determi from the location of seeds inside the fruits, and also from the s of seeds. Elaborate trials conducted at Kodur (Madras) h shown that all these assumptions are unfounded. Sakurai (30) also obtained negative results in regard to the relation of the se the location of seeds in different parts of the papaya fruits, as als the size of seeds to sex. He further states that no relation ex between size of seedlings in seed beds and their future sex. Cha of sex of a male by pruning or topping of the tree, cannot a be depended upon to give uniformly successful results. Re (28) has shown that contrary to the existing belief, the margin the intial leaves, the colour and vigour of the stem, and the s or extent of the root systems of young papaya seedlings are individually or collectively associated with male or female ch acters. He also did not find any positive results in regard to control of sex by cutting off the central root systems or topp once or even twice or thrice. The light topping consis of pinching off of the terminal bud was followed by slight changes, but several forms produced no positive respo Hofmeyr (19) found that no ground exists for the assumpt that the male trees are more vigorous and, therefore, the eli nation of vigorous seedlings while transplanting is merely destruction of best plants.

As it is difficult to determine the sex of seedlings at the t

f planting, generally two or three seedlings are planted together ı each pit in the Bombay Presidency, and when flowers appear n them, male and hermaphrodite plants are removed, leaving ıe females with a very few male plants in the plantations.

As papaya presents varied sex problems, there appear to be ossibilities to breed papaya with a view to combine most desirable characters and subsequently propagate such a newly evolved type vegetatively or by self-pollination or by sib-mating in order to eep it stable through generations. According to some authors ıe ideals which the breeder should have in mind in breeding ıe most desirable type of papaya are outlined below:—

mprovement in papaya

1. Vigour of tree.
2. Early and low-down-on-the-trunk fruiting habit.
3. Freedom from branching habit.
4. High productivity.
5. Hermaphroditism.
6. Suitable size of fruits.
7. High yield of papain.
8. Uniformity of shape.
9. Uniformity in ripening.
10. Appearance of colour before softening.
11. Attractive colour of flesh.
12. Easily separable placenta.
13. Agreeable flavour and taste of pulp.
14. High keeping quality.
15. Ability to produce progeny with the least number of variables.

[ofmeyr (19) considers that contrary to the existing belief, a ven papaya strain can definitely be improved by selection in ite of the trees being diœcious, particularly if selections are ıade from the centre of the plantations, when there are eighbouring groves. The other way out of this difficulty ould be to select and purify by isolation and artificial ollination selected strains of known quality. Seeds thus roduced should be certified as belonging to such strains ıd distributed for raising plantations in the country. o seeds produced in the open plantations under natural conditions should ever be used for raising new plantations, if mixture

and deterioration of papaya strains are to be prevented. Th would mean that the State should establish papaya breedi and seed distributing stations, which will have to work for t planters year after year, producing pure seeds by artifici pollination of known and fixed varieties. The principle unde lying this plan is exactly the same as that of seed distributi stations in the case of cereals, cotton and the like.

Yield and economic value

Papaya plants yield harvests in twelve to fourteen mont from the time of transplanting seedlings and thus bring a fair quick return to the growers. This fact e hances the value of the crop. In the Bomba Presidency (10), the papaya tree is found bear on an average 27 fruits per annum, with an avera weight of 2·2 lb. each. The maximum yield from single tree recorded was 104 fruits weighing 203 l Of course, the yield varies according to soil, treatmen climatic conditions, etc. Several important papayas, *e.g* Bangalore, Honey-dew, Washington, etc., have been tried the Fruit Research Station, Hassarghatta, Bangalore. Th average yield comes to about 8,840 fruits weighing 30,140 lb. i an acre plot. In this area the average number of fruits p tree was 22. At the Hawaii Agricultural Experiment Statio papaya trees of 7-8 months of age yielded 28 to 38 fruits eac with their total weight varying from 19 lb. to 36 lb. per tre The yield obtained in the Bombay Presidency and Mysore co pares very favourably with those of plantations in other tropic countries. The income in money value may vary accordin to the marketing conditions. At any rate, this crop is found to among the highly paying fruit crops in Western India. The li of papaya plantation can be prolonged up to ten year But the really productive and hence economic period is on the first three years of its life. After three years it would advisable to renew the plantations.

Maturity

The proper state at which fruits should be harvested considered to be when their stigmatic end becomes slightly ye low. When the fruit is oval and ribbed, the yellow tinge fi appears on the ribs towards the stigmatic end of the fruits. T appearance of yellow tinge is the first a true indication of the full development of t fruit. Then it can be harvested and allowed to ripen in t

Sherman (32) analysed fresh fruits and gives mud composition as follows:—

	As purchased	Edible portion					Fuel Value	
	Refuse	Water	Protein (Nx 6·25)	Fat	Carbo-hydrates including fibre	Ash	Per 100 gms.	per pound
Papayas ..	32	88·7	0·6	0·1	10·0	0·62	43	195

Work done in India on the analysis of papaya reveals the following figures:—

Name of food	Botanical name	Moisture %	Protein %	Fat (Ether Extracves) %	Mineral matter	Fibre	Carbohydrate %	Calcium (ca) %	Phosphorus (P) %	Iron (Fe) mgs %	Calorific value per 100 gms.	Carotene (International Vitamin A Unit) per 100 gms.	Vitamin B (1.U. per 100 gms.).	Vitamin C mgs. per 100 mgs.	Calories per ounce.
Papaya ripe	*Carica papaya*	89·6	0·5	0·1	0·4	—	9·5	0·01	0·01	0·4	40	2,020	..	46	11

store. Fruit which ripens on the tree turns out to be sweete than fruit picked earlier and ripened in the store. But suc fruits are likely to be attacked by the Mediterranean fly resultin in maggots, or by crows and other birds. Dropping of fruit while picking softens the injured part lessening the keepin quality of the fruits.

The papaya fruit has a very high digestive value due to th papain—a protein-splitting enzyme, which it contains. Papay compares favourably with oranges as a source of calcium, basi

Food value

ash and ascorbic acid. Vitamin C content o papaya increases with the ripeness. Averag papaya is estimated to contain per 100 gms. of edible materia 2500 international units of vitamins A, 8 international unit of vitamin B1, 70 mg. of ascorbic acid (vitamin C) and 3 Bourquin—Sherman unit of vitamin B2. (37). According t Daniel and Munsell (11), *Carica popaya* contains 3,000 Inter national Units of vitamin A, 8 International Units of Vita min B, 70 Sherman Units of Vitamin C and 33 Sherman Units o Vitamin G. (Also see pages 303, 305 and 306.)

Ripe papaya, however, is said to contain little or no papai (22). It is considered to be a wholesome and nutritious food an used at all stages of development. It is said to cure chroni constipation and piles. It is claimed to set enlarged liver an spleen right. The fruit is a valuable tonic. Ripe fruit of papay contains about ten per cent sugar. It is used in a variety o ways. It is a highly relished table fruit for breakfast and i prepared in a number of ways into delicacies.

The general composition of the papaya fruit is worked ou at the Hawaii Agricultural Experiment Station (25) and is show by the following figures:

	per cent
Water	90·75
Protein	0·80
Fat	0·10
Fibre	1·09
Nitrogen-free extract	6·32
Ash	0·94
	100·00

Mineral constituents in edible portion of the papaya as reported by Rosedale (29) from Malaya.

Water	Ash	Cl	P_2O_5	CaO	Mg	Na	K_2O	SO_4	Fe	Cu (mg. in 100 gms.)	Mn (mg. in 100 gms.)	I (mg. in 100 gms.)
89·0	0·10	0·0036	0·007	0·004	0·00312	0·0030	0·039	0·0016	0·00126	0·10	—	0·9

The fruit flesh has been analysed by Pratt and Del Rosario (12) Thompson (34) and Adriano (1) and their average results are :—

	Flesh in fruit	Solids Total	Solids Insol.	Protein	Fat	Acids as Citric	Sugar reducing	Sucrose	Fibre	Ash	
	%	%	%	%	%	%	%	%	%	%	
Female	47	10·50	1·60	0·44	—	0·14	5·38	0·38	—	0·58	Pratt and Del Rosario
Hermaphrodite	63	10·40	1·50	0·50	—	0·15	5·82	0·07	—	0·51	Pratt and Del Rosario
	71	12·01	2·00	0·59	0·10	0·15	8·99	0·54	1·37	0·61	(Thompson)
I	70	11·19	—	1·18	0·24	—	—	—	1·66	1·22	Adriano
II	64	12·28	—	1·32	0·17	—	—	—	2·68	0·53	Adriano

Thompson (34) tabulates results on the fruit flesh of payaya at ripeness and before ripeness.

The composition at three of the dates given below shows the trend.

	Flesh in fruit	Solids Total	Solids (Insol.)	Protein	Fat	Acids as Citric	Sugar reducing	Sucrose	Fibre	Ash
Before ripening	%	%	%	%	%	%	%	%	%	%
5 months	71	6·48	3·28	0·80	0·21	0·09	2·15	0·23	0·37	0·62
2 weeks	79	6·45	2·49	0·31	0·26	0·06	4·13	0·47	0·58	0·43
Ripe	83	10·59	1·05	0·39	0·19	0·08	8·02	0·00	0·69	0·57

Fruits of a few papaya strains from Hawaii (25) have been analysed by Alice Thompson at the Hawaii Agricultural Experiment Station. Their composition is given below:

Strains	Total solids	Ash	Acids as H_2SO_4	Protein	Sucrose	Total sugars	Fat	Fibre
	%	%	%	%	%	%	%	%
Trinidad	12·14	0·53	0·06	0·43	0·74	9·72	0·06	0·78
S. Africa	13·60	0·54	0·09	0·68	0·53	10·73	0·07	0·81
Honolulu	12·20	0·56	0·07	0·50	—	10·29	0·05	0·66
Barbados	11·72	0·48	0·06	0·46	—	8·95	0·06	0·76
Panama	14·41	0·90	0·14	0·50	1·26	11·12	0·25	1·09
Tahiti	10·19	0·67	0·17	0·90	0·94	8·44	0·05	0·79

Jam, marmalade with orange rind fringes and pickle are some of the products that are made from papayas in India.

Preserves

At the Kodur Fruit Research Station, papayas have been found to be an excellent ingredient to be mixed with pineapple and mangoes in canning fruit salads. The bright colour of the pulp of papaya adds a distinctive attractiveness to the fruit salad and blends well with the golden yellow colour of the pineapple and varied tints of the mango pulp, rendering the salad very pleasing to the eye as well as to the palate.

Papaya fruits are packed in bamboo baskets for transport to local and short-distance markets in India. For

Packing

purposes of export to distant inland and foreign markets, they are packed in wooden crates, where fruits can be laid in single layers. The size of the crate may be adjusted according to the grade and number of fruits in each pack. It is found advisable for easy handling that each crate should contain not more than six fruits. Individual fruits are wrapped in paper and the interspace is stuffed with straw or softer grass to avoid injury due to shaking in transit. Fruits from Hawaii marketed in San Francisco and British Columbia are usually wrapped in paper with a packing of corrugated straw-board in between the two and then packed singly in crates holding four to six fruits each (25). Fruits which are long in shape with a small cavity and few seeds are often priced higher in the market than others. Such fruits are easy to pack and travel well. They also contain more edible matter than fruits with larger cavity. Large and thick fruits with comparatively larger cavity are generally delicate and get bruised in transit.

Papaya fruits vary in size to a very considerable extent. The shapes of fruits also differ. Some are large, some small,

Grading of fruits

some long and cylindrical, while others are oval and bulging. Fruits are, therefore, profitably marketed by grading them into different classes according to these characters. A trial at grading papaya fruits was conducted on a limited scale at the Modibag garden at Poona (6). The fruits taken for observation were of the Washington type. Larger fruits of impressive appearance were found to be always preferred by well-to-do families and for purposes of presentation.

They, therefore, commanded a much higher price than fruits sold for their collective weight. For transport to distant markets medium fruits are preferred as they can be packed well and stand transport better than very large fruits. Small fruits are easily sold to the poorer classes at cheap rates.

Storage

High temperature in storage hastens ripening of papaya fruits which may become soft at places. Low temperature prolongs the storage period to a certain extent. If fruit is picked at the proper stage of maturity it can be stored from three to four weeks in a saleable condition at 40°F to 50°F. Fruits picked and stored on these principles were sent from Poona to the United Kingdom in good condition. Wardlaw, Leonard and Babar (38) state that fruit which is yellow but firm in consistency appears to be best suited for export under storage temperature of 45°F. Such fruit can last for about twenty days. Spoilage in storage is found to be due to *Gloeosporium fusarium*.

Extraction of papain

One of the very important and economically manufactured products in commerce obtained from papaya fruits is the papain. The substance marketed under this name is the dried milk of raw papaya fruits. As it occurs in commerce, the papain is a greyish powder, which resembles animal pepsin in appearance, colour and taste. The commercial papain is not quite pure, as it is invariably adulterated with starch, bread, arrowroot, milk of white cactus, gutta-percha, boiled rice, etc. The Indian method of adulterating papain with boiled rice (10%) is considered undetectable.

The milk (latex) of raw papaya is tapped by scarification particularly when the tree is young and during the warm weather. The juice flows well in the morning. The surface of fruits is longitudinally scratched with some sharp non-metal instrument such as a bone knife or ivory piece. It has been suggested that even metal knives can be used without any ill-effect. The juice begins to flow and is collected in shallow pots held beneath. If the flow is poor, the juice may coagulate on the surface of the fruits. It is then scrapped and immediately dried in the sun or in driers. Drying under shade gives a white attractive product. Ordinary shallow pans serve as a good receptacle for the juice for drying. A suitable temperature for drying is considered to be about 100°F and the time taken may be about

24 hours. It is reported that in Ceylon, latex is extracted, stirre vigorously till coagulation, passed through a squeezer and su dried or even dried at 50°C to 55°C in a dehydrator (8 The dried juice is used either in flakes or in powder form.

Preparation of papain deals with an important commerci aspect of the papaya crop. Papain is prepared in several tro pical countries and there is a possibility of its being manufa tured in Western and Southern India also. The problem a present is how to get papain of a superior quality for which goo price can be had in the market. It is necessary that the metho of decoloration and dehydration of the product should b properly worked out to suit Indian conditions and once for a decided whether it pays to produce papain or not. A larg number of enquiries are now being made on this subject by th public. On the Baroda Agricultural Experiment Station, papai was extracted from raw fruits of the Honey-dew variety of papay with very good and promising results. The dried milk o papaya gave a fine whitish powder, easily comparable with th commercial papain, although the former was not purified. O analysis, it was found that the Baroda product could digest 12·4 times its weight of fibrin at 70°C, while commercial papayoti digests 5·34 times its weight. The Baroda product containe 3·9% ash as compared with the pure papain in which the per centage of ash does not exceed 0·2%.

The economic importance of papain extraction in this part o India depends upon whether papain can be prepared as by-product of papaya fruits. If papain has to displace th fruit crop by spoiling the fruits, which fetch a good pric in our market at present, it does not seem to have much futur If, on the other hand, papain can be extracted fron fruits which remain still saleable at a reasonable price o ripening, then it is worthwhile trying the extraction of papa on a large scale in papaya plantations. Experience on th line at Kodur has shown that the fruits that were tapped for pr paration of papain lend themselves very well for canning an manufacture of candied papayas. Such fruits can also be use for the table, even though the outward blemishes may low their fresh fruit value. Sanyal (31) estimates the yield of papa at half a pound per tree, and from his observations relating papain manufacture in Ceylon, he concludes that "The papa

ndustry in India would also be quite lucrative." In Ceylon he yield of papain from an acre of papaya plantation is bout 175 lb. in the first year, and later it is estimated at 100 lb. er acre. Four and a half pounds of fresh latex yield one pound f dried papain. Papain extraction has been tried at the Fruit Research Station, Hassarghatta. It is observed that 100 lb. of ong fruits yielded 171 grams of crude papain. The yield from ong fruits is higher than the yield from round fruits.

Ceylon at present holds the monopoly of export of apain to Europe and America in large quantities. If better nethods of extraction and preservation are evolved and means f keeping the colour of the product white, are found out, India an expect to compete with Ceylon in the export of papain to hose countries even though the higher cost of cultivation in nost parts of India may be a handicap.

It is observed that East Africa has a prosperous papain ndustry developed around Arusha on the slopes of Mount Meru nd Moshi.

The exports of papain from Colombo are given below:—

			Quantity lb.
1932	..	..	64,356
1933	..	..	100,046
1934	..	..	103,778

The price of Ceylon papain during the years 1930, 1931 and 932 was 7 shillings, 5 shillings and 6 pence and 5 shillings and pence per lb. respectively. But the price fell as low as shillings and 9 pence per lb. in 1933 and again rose in 1934 6 shillings and 9 pence. This serves to give a comparative lea of the ruling price and extent of fluctuation.

Diseases and pests f papaya

Papaya is free from many serious diseases so common with ther fruit trees. However, stem-rot (24) sometimes causes considerable damage to this crop. It is caused by the fungus *Phythium aphanidermatum* which is soil-borne. The symptoms of the isease are that the trunk of the tree rots at the collar the point where it touches the soil or where the root ends nd the stem commences), and the leaves wilt. Water-logging

is the chief contributing factor, as the fungus thrives well un such conditions. Scraping off the affected parts and smear coal tar, Bordeaux paste, and dilute carbolic acid were tried Kodur (Madras) to combat this trouble but with no apprecia effect. Further light requires to be thrown on the control this disease. It can be checked by preventing water stagnat at the roots, which is the best preventive measure agai this disease.

Of insect enemies of papaya, red spiders are the m important. Red spiders or mites are sometimes found on surface of ripe fruits or leaves. The leaves turn yellow and fruit becomes roughened with brownish colour when attacked mites. Dusting with sulphur or spraying with lime sulphu an effective control.

When papaya trees attain a large height so as to ma harvesting difficult, the trunk may be cut off at about th

Rejuvenation

feet from the base. This induces a la number of buds to sprout, of which o two or three are retained, the rest being removed. Th sprouts ultimately become bearing trees. This system practised to a small extent in the districts on the West Co of Madras Presidency.

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CHAPTER VII

GRAPE (*Vitis Vinifera* L).

Introduction

The grape although limited to a small acreage, is a high specialized crop in the Bombay Presidency. The climatic cond tions of the Deccan are not very suitable f the cultivation of choice varieties, but d to equable temperature, the vines bear fruit during winter a the fruit is available for sale in the months of February to Apr when the superior table grapes produced in the countries to t North-West of India are not on the market. An equable clima and off-season fruiting are, therefore, the factors which encou age grape cultivation in this part of the country. But whe ever the temperature reaches the freezing point, considerab damage is caused to this crop. Frequent losses due to fr during the last decade have undoubtedly checked and di couraged the extension of grape cultivation. As stated above, t quality of grapes grown in the Bombay Presidency is not ve superior, and this fact retards to a certain extent its extension acreage. Nevertheless, its cultivation affords a very intensi kind of farming, and if a full crop is harvested, it gives a fair good income to the grower. It is principally on this grou that the importance of grape is recognised.

Origin and distribution

It is difficult to locate the original home of grape vines, but appears to be a native of Asia having originated in the Caucas regions. According to Alphonse D'Candol (29), records of the cultivation of gra vines in Egypt go back to 3,000 to 4,000 B. Viticulture was flourishing in Greece in the time of Hom Grapes are widely grown in several countries of the world. Th grow almost in all countries of Europe, United States of Americ parts of Africa, Queensland, South Wales, Palestine, Pers Afghanistan, South of China and Brazil. Ninety per cent commercial grape culture in the U. S. A. are centered on t Pacific coast, where European varieties are grown for t production of table grapes, raisin and currant grapes and f wine purposes. In the rest of the country, hybrids and nat grapes are grown.

In India grape growing is restricted to Kashmir, the ınjab, the Deccan and the Madras Presidency.

Baluchistan in Pakistan with an acreage of 2,429 under apes, supplies table grapes to almost the whole of India from ptember to December. Raisin grapes are also obtained in rge quantities from Afghanistan, North-West Frontier Province id Baluchistan. In the Punjab, viticulture has not yet ken a real foothold, but a few early varieties bearing crops fore the advent of the monsoon appear to be gaining some pularity. Formerly, inferior varieties like *Tas*, *Tor*, *Sursavi*, *insavi* and shy bearing *Kishmish* and *Bedana* were the main ltivated varieties in the Punjab. Muscat and Sultana edless introduced from Australia had also been tried ily with uncertain results. Even the introduced early varieties e subject to considerable damage by periodic hail and dust orms and premature rains during the harvesting season. In uth India an inferior variety of grapes is grown fairly extenvely in Michaelpatti and Vellodu in Madura districts and rishnagiri in Salem district and in and near Bangalore. uring the last decade the seedless Kishmish was introduced South India and has acquired an unexpected popularity ıder a most intensive and distinctive method of culture.

In the Deccan, grape is grown chiefly in the districts of Nasik, oona and Ahmednagar. The total area under grapes is 964 res in the Bombay Presidency. Most of the acreage is conned to the Nasik District. There are several other tracts such the Nira right bank canal, Sholapur and Bijapur where apes can be grown in this Presidency. Grape cultivation has en recently introduced into Gujerat tract also with fair ccess. The acreage of grapes in India is as follows:—

Bombay	..	.. 964 acres
Madras ..	..	.. 350 ,,
Hyderabad	..	.. 100 ,,
Mysore	..	.. 50 ,,
	Total	.. 1464 acres

Grape belongs to the Natural Order *Vitaceae*. There e three broad horticultural groups under which all

Varieties and their classification

the cultivated types of the genus can classified. They are:—

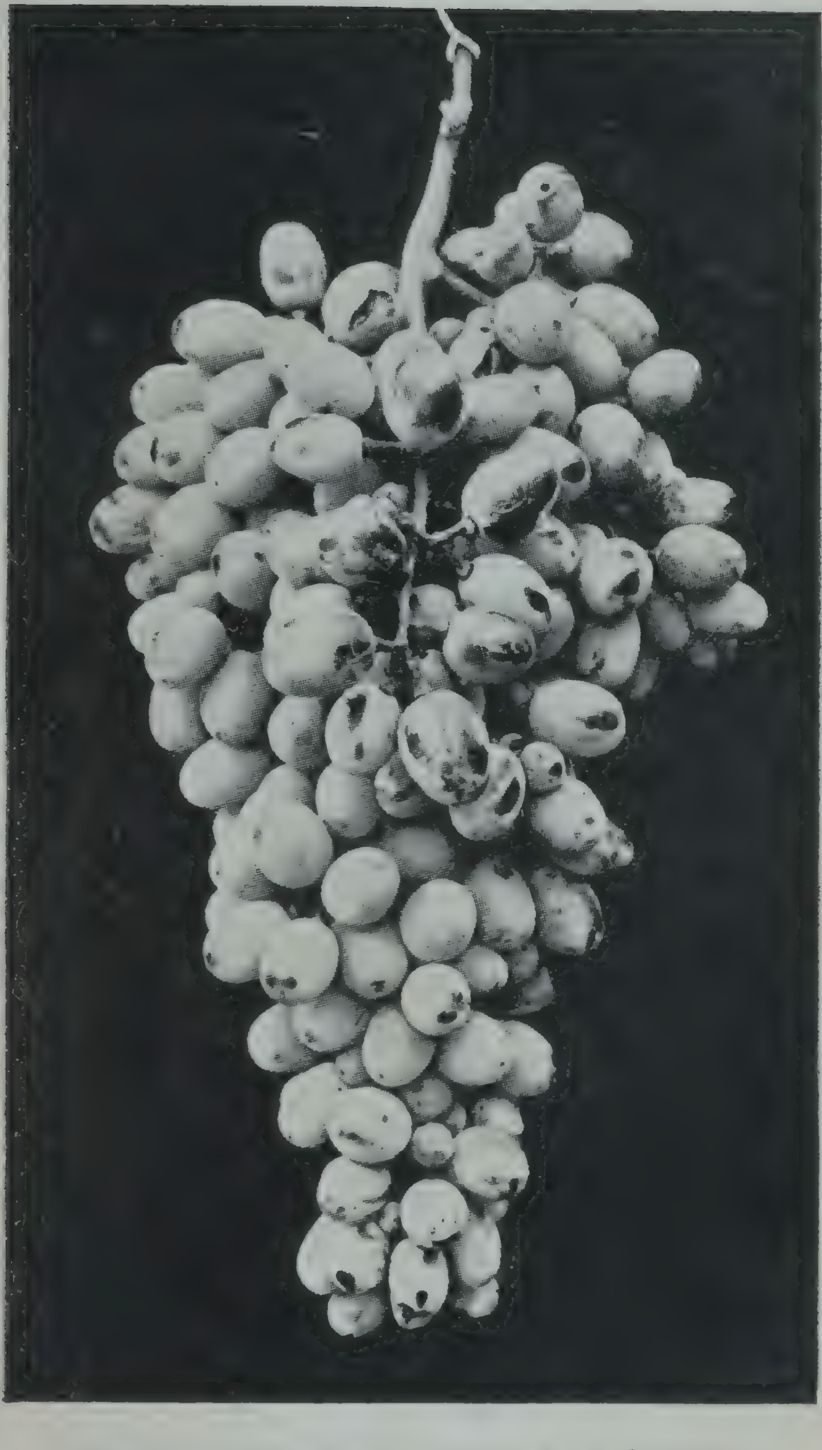
1. *The table grapes*, such as *Fakdi*, *Bhokari*, and *Kali* a *Pandhari Sahebi*.
2. *The raisin and currant grapes*, such as Sultana a Thompson Seedless.
3. *The juicy grapes*, such as Muscat and Black Prin which are principally used for making wines, b tling fresh juice, etc.

The table grapes are either large or medium size black, greenish white or pinkish in colour a are sweet with but few seeds and a thin or thi skin.

The raisin grapes are large, medium sized or sma berries. They are black or greenish white in colou They may or may not have seeds. They have a hig percentage of sugar and have either thin or thi skin. All raisin grapes grown in the U. S. A. a produced in California. They were first introduce there in 1851. Some of the varieties are Sulta from Spain, White Corinth and Red Corinth fro Crimea and Alexandria. The fruit of Alexandr variety ripens in mid-season and its colour yellowish green. The bunches are long and loos It has an attractive appearance and a peculi flavour. Sultana can be grown without irrigati but to get good fruits, irrigation is necessar Thompson Seedless is closely allied to Sultana. A these varieties have large bunches, with mediu sized berries of good quality.

The juicy grapes are either black or whitish. Th have a strong aroma which is a distinct characte The sugar content is high and the juice is slight acidic. They are chiefly used in making win All the juicy types such as Muscadine fall und this group.

European or vinifera grapes (*Vitis vinifera*) form 90% the cultivated vines in the world. Stress has been laid in so countries on breeding work to evolve suitable varieties, bett adapted to local conditions in tropics.



BUNCH OF BHAKARI VARIETY OF GRAPES.

Facing page 318.

Grapes in the Bombay Presidency are chiefly consumed as resh fruits. Their cultivation is very limited and there is no rying, bottling or wine making of grapes in this part of India. he following are the chief varieties grown here.

The *Bhokari* is a common variety grown on a commercial cale in the Bombay Presidency. It is the highest yielder of ll the local varieties and is, therefore, the chief commercial ariety. Its vine grows vigorously and has a round stem. It as a red pigment on young shoots and veins on leaves. Leaves re deeply lobed and dentate. The basal leaves have wide aps, curving away from the leaf stalk. Bunches are large, ompact, long and tapering. The central portion of the bunch cylindrical while the upper part is thinly shouldered. When ully ripe, the berries develop a faint rosy bloom and become rge and round. The skin of berries is thick and leathery. he pulp is luscious and acid sweet in taste. The texture of the ulp is soft and watery. Seeds are hard to chew. Berries do ot keep well for long. The cultivation of this variety is con- entrated at Nasik and scattered in other areas.

Next to *Bhokari*, *Fakdi* is the most important commercial variety n this Presidency. The *Fakdi* vine is the most vigorous of all he varieties grown in Western India. The main characteristics f this variety are that it has a thick flat wood with the basal ortions and trunk of ripe canes flat and grooved. Its yielding apacity is lower than that of *Bhokari*, but in a favourable season can compete with the latter. *Fakdi* yields a quality of rapes superior to *Bhokari*. *Fakdi* leaves have shallower lobes an those of *Bhokari*. The segments at the base have narrower aps, which do not curve away widely from the leaf stalk. unches are very large, loose, irregular and heavily shouldered, eing often wider than long. They are usually smaller in size an those of *Bhokari*. The colour of berries is watery green, and evelops a bloom when ripe. Berries are oval in shape. The ulp is soft, sweet and watery. The skin is thin and soft. *Fakdi* not a good variety for shipping or for long transport, but being ery sweet in taste, it fetches a better price than *Bhokari*.

Pandhari Sahebi makes slow growth in Western India. The unk and the canes are slightly flat. The canes are thick stout nd short. This variety is partially self-sterile and hence a shy earer. Its leaves are large and rough. Leaf-stalks are stout,

having prominent veins with rounded teeth. Bunches are usua loose, most of the berries are "shot grapes" with no pips insi owing to the imperfect pollination. The shape of pollen gra is irregular. This variety is grown along with *Bhokari*, which a self-fertile variety. The colour of berries of *Pandhari Saheb* whitish and develops an amber bloom when ripe. Owing to attractive colour of its bloom and the high quality of berries, i called *Pandhari Sahebi* (white big grape). It is a suitable ta variety of grapes grown in some parts of the country for dista markets as its keeping quality is relatively high.

Kali Sahebi (black big grape) is a dark purple variety, and i vigorous grower. Its yielding capacity is low. Leaves are da green with deeply incised margins. The lobes are compa long and broad at the base, and very heavily shouldered. B ries are long in shape, thicker at the base, cylindrical and sligh drawn in, in the middle, and distinctly flattened and depress at the stigma end. All berries do not ripen simultaneous It is a late variety requiring about fifteen days more to rip than *Bhokari*. It is green when raw, but turns dark purple wh ripe. Its pulp is firm and sweet in taste. The skin is thin. stands second only to the *Pandhari Sahebi* in keeping quality. Fr stalks are slender and weak, which makes the berries drop wh picking and packing.

Kandhari vines grow vigorously in the Bombay Presidenc The upper side of leaves is dark green while the veins on t underside are reddish. Leaf margin is serrated. Basal lobes a slightly inside, over-lapping and somewhat hiding the leaf sta Bunches are of medium size, very compact and rectangular shape. Berries are of medium size, thick-skinned, sweet a dark purple when ripe.

Black Prince is an early variety. It grows vigorous yielding a prolific crop which matures earlier than that other varieties in this part of India. The wood is thin, round a short-jointed, having short canes. Leaves are greenish yellow colour. Bunches are of medium size, with many "shot grapes cylindrical and pendulous. Berries are of medium size, thic skinned, highly aromatic and sweet. When fully ripe, the berr assume dark purple colour. Berries do not ripen simultaneous This variety is not grown on a commercial scale.

Neelum is a variety of inferior quality. Its leaves are thic

i-lobed with the lower side thickly covered and with white ubescence. It is a slow and shy sprouter. Bunches are small, ompact and cylindrical. Berries are dark purple, round and nall, with thick skin and acid taste. Berries ripen earlier by fteen to twenty days than in the case of other varieties.

An ideal soil for grapes in Bombay Presidency would seem to e a loam with good drainage. Vines grow very vigorously when the soil is loose and has perfect aeration. However, the grape is being grown on a va- ety of soils with fair success, provided such soils are well drained. n the districts of Poona and Nasik, grape vines are growing on lack, medium black and shallow light soils, which have murum s sub-soil. In the Punjab and Sind, any soil is considered su- able for vine cultivation if it does not contain a high percentage f harmful salts. The depth of soil is not considered in this residency as important, as the roots of vines generally do not enetrate very deep, not beyond about three feet ordinarily in eccan. *Chopan* or clayey soils as well as those having a hard sub- ratum are not selected for vine growing. Lagatu (51) and others ention that "The addition of large amounts of potash is neces- ary initially to replenish the potash deficiencies caused in the soil, elected for grape vines." Chauzit (21) is of the opinion that the ield in grapes increases in the proportion of sulphur used. The ffect of sulphur is pronounced if there is a large quantity of orga- ic matter in the soil. The amount of sulphur used is 200 kgms. er hectare. The most dominant plant food of vines is said to be otash. Granite soils are rich in potash and felspar, and, erefore, they produce grapes of excellent quality. Soils rich lime are very suitable for table grape. Grape vines are nong the most resistant to soluble salts in the soil. They are und to grow well on soils containing 77 parts sodium chloride t of 286 parts of total salts per 100,000 parts of water.

oil

In Baluchistan a hard black soil is preferred for Speen *ishmish*, a hard reddish soil for *Haita* and a sandy or gravelly il for all other kinds of grapes. The soil used for grape grow- g in Nasik is a medium black soil with a lime content of from 3 5 per cent. In South India, the maximum success has een achieved in soils which are very open and gravelly. Such ils have a perfect drainage and being hungry, they respond agnificently to care.

Climate

Climate is an important factor influencing the cultivation c grapes. A close study of the climate of grape growing tracts i different parts of the world shows that as fa as possible, it must have a warm and rainle summer, during which the ripening of fruits takes place. Heav and long continued rains also affect the keeping qualit of the fruits. The ripening period should follow a good perio of resting, during which the vines are fully or almost complete leafless. Lack of such conditions makes grape cultivation unce tain and risky and tends to lower the quality of fruits produce In the heavy rainfall districts of the Bombay Presidency, grap vines make a poor growth, which, coupled with the local practic of pruning them twice a year, retards fruit bearing. It is observe after many trials in the Konkan and the Karnatak that grape vine do not yield profitable crops in heavy rainfall tracts. In such place they bear a few bunches of rather inferior quality of fruits an are prone to a serious attack of mildew and anthracnose disease Tracts like Bijapur, Sholapur and the Nira right bank, wher rainfall is not heavy and the climate is dry, are suited to grap vine cultivation, if the soil is suitable and if there is enough irriga tion facility.

Because of the equable climate, grapes in the Deccan an South India do not enjoy a long dormant season as in the leadin vine growing regions of the world. The relatively long period of growth and the absence of a prolonged resting period, rende grape vines and their crop open to serious damage by frost which though uncertain occurs once in a way in Western India In the grape growing regions of South India, frost, dust an hail storms are practically unknown, but despite this fact, th quality of fruits produced is low. It remains to be seen if the in troduction of better varieties or the breeding of varieties whic combine the hardiness and productiveness of indigenous typ with the quality of choice exotic ones will be profitable. Th very useful character associated with South and West India viticulture is maturing of crops in a season, when grapes fro Northwest of India and Baluchistan are scarce. The wid popularity enjoyed by grapes throughout India, render breedin investigations and extensive orchard trials with importe varieties certainly worth while. Sind and the Punjab have warm summer, but occasional rains, dust and hail storms occu

ust at the time when the berries develop seriously damaging he crop. Northern India does not therefore present a suitable climate for the cultivation of choice varieties of grapes. Winkler 84) points out that climate affects the quality of table grapes. He finds that in cool seasons, acidity is relatively high in relation o sugar contents, and in hot seasons it is relatively low. Dry weather at the time of ripening is very helpful and favours the preservation of fruits.

Propagation

Commercially grape vines are propagated by cuttings of eight o ten inches length, taken from fully mature wood of about six months of age. In the Bombay Presidency cuttings are prepared in the month of October when vines are pruned for the sweet crop. Canes with moderately short internodes are chosen for taking cuttings from their mature basal portions. Bioletti (10) suggests that a good cutting should consist exclusively of healthy one-year old wood, and should have been taken from vines that have borne heavy, but not excessively heavy crops. Young vines generally produce immature cuttings, while abnormally heavy producing vines possess mostly ill-nourished cuttings. Bioletti and Jacob (13) have found that the popular belief that large sized cuttings produce larger vines is not correct. Though the influence of the size of cuttings was marked in the beginning, later in the vine yard, it largely disappeared. Winkler (82) has found that oxidising agents hastened callus and root formation and improved the rooting of grape vine cuttings. Quinn (66) states that the nature of the season affects the striking of roots in cuttings. The temperature favourable for this appears to range from 50°F to 53°F in the soil at the base of the cuttings.

Cuttings are planted in October in the Bombay Presidency, n beds in a slanting position and are allowed to remain there ill the following January, when they are transplanted in the field. During this period of three to four months, cuttings strike a fairly large number of roots and are ready to be successfully transplanted. Vines can also be propagated from seeds, but owing to the variations produced in seedlings, seed propagation s adopted only for breeding and selection of desirable types. Woodfin (86) states that some settlers have successfully introduced the method of grafting vines in New Zealand. They plant cuttings meant to serve as rootstocks in their

permanent positions with the scion wood planted nearby betw
rows of rootstocks. Grafting is done when the rootstock cutti
start growing. "Over-grafting" or top-working of Ameri
varieties is practised in the vineyards of some countries. T
method is used for converting inferior varieties into better or
Some varieties of American and hybrid (American-Europe
grapes are more or less resistant to the attack of the phyllox
trouble. Though they may not all be immune to its atta
their root system is hardy enough to withstand the effe
of the attack. So, wherever the attack of phylloxera is fear
these resistant varieties are recommended as rootstock pla
for grafting upon. Budding and grafting of grape vines a
also resorted to in some countries, where certain undesiral
varieties require to be replaced by better ones. Howev
budding does not appear to be extensively practised.

A method known as bud-graft or *yema-graft* is also in use
Spain, Italy and California. It is a form of side graft, in wh
the scion is a single bud with a piece of wood attached to it a
joined to the rootstock from which an equal piece of wood
removed previously. Whip, cleft and side grafting with lo
scions are also practised on a small scale, especially on old vir
with scions of past season's growth. Bench-grafting is al
possible with grape vines. Bioletti (8) found that bench gra
of vines callus best in sand containing five to ten per cent
moisture, and they are more successful than other methods
grafting. Grafting is a profitable practice, where it is n
possible to get a good crop from own rooted plants due
the attack of phylloxera or other causes. So far no necessi
has been felt to raise vines by grafting on disease-resistant roo
stocks in Western India. Layering is also used in propagati
vines and is useful in filling gaps in the orchard, as it gives larg
plants. Propagation by single-eye cutting is a useful method to
where a valuable variety is intended to be multiplied. Layeri
vines of all ages upto hundred years of age is found possible.

Before planting an area with grape vines it is essential to t
the soil properly and to add humus to it. Thorough deep ploug

Preparatory tillage and planting

ing and the application of a good dose of far
yard manure to the soil is considered necessar
Ploughing in *sann* hemp (*crotolaria juncea*)
green manure prior to the planting season is recommende

its of $1\frac{1}{2}$ ft. by $1\frac{1}{2}$ ft. and $1\frac{1}{2}$ ft. are taken at eight to ten ›et apart. They are filled with the original soil mixed ·ith about twenty pounds of old farmyard manure. At mes a small quantity (2-3 lbs.) of oil cake is also applied › each pit. In some parts of South India, the pits are lled with alternating layers of green leaves and tank silt ntil flush with the ground level. Occasional watering is one to the filled up pits to facilitate decomposition of the reen leaves prior to the planting of the vine. In some laces a small amount of bone meal may also be added with he green leaf. Rooted cuttings are then planted singly or wo or three of them being used together in each pit. Grape ines, being very susceptible to white-ant attack in the early tage of growth, it is advised not to add any manure, especially he farmyard manure, to the pits at the time of planting in ›calities where the attack of white ant is feared. In fertile oils, it may not be necessary to add any manure to the soil i·l about a year after planting.

Planting is done during the month of January in Western ndia. It is essential to give a support to the vines in ach pit, immediately after they are planted in the field, as xplained later. The sprouts which shoot from side buds are ubbed off, and the vines are usually allowed to grow into single anes. Care is necessary in handling the vine roots at the time of lanting. Roots of young vines are tender and may be jammed r injured at the time of lifting. All such injured roots are rimmed off at the time of planting and the healthy ones are ıortened. The top is pruned to a single cane when only ne cane is desired to be retained. The cane or canes that are etained have to be cut back to two or three buds or eyes, soon fter or prior to planting. This pruning is essential where ines are to be grown by any of the American methods of training nd pruning described elsewhere.

Instead of rooted cuttings, only the cuttings taken from the inter prunings are commonly used for planting in some places ı South India. Such cuttings rarely get damaged by white nts and grow vigorously in the rich media inside the pits, due to ıe rich mixture of green leaves, silt and bonemeal applied some ıonth previously and well decomposed by the time cuttings are ›ut down.

In California, the distance of planting varies from eight ten feet, the former spacing being more prevalent. Great space is provided in raising plantations, in which case even fou teen feet spacing between vines is not unusual. A few rows vines are left out here and there to provide avenues for conv nience of access to the vineyard. In parts of Central an Southern Europe, grapes are planted on hill slopes with spacing of only 2 to 3 feet.

In the Deccan the support generally given to vines soo after planting is some kind of temporary stick planted near th base of the vines. When the vines begin t grow large stemcuttings of *pangara* (*Erythrin indica*) are planted in the monsoon which strike roots and replac the wooden sticks originally given forming a permanent suppor to the vines. If *pangara* stems are not available, wooden stake can be substituted for them or trellis may be prepared to trai vines upon. *Commiphora beryii* is the most commonly used liv stake in Madras Presidency. Several systems of training vine have been tried in the Deccan. The single-stake or *pangar* system is, however, the most commonly adopted one. It con sists of planting vines eight or ten feet apart, and when the have grown to a height of six to seven feet on the temporar sticks they are headed back to a uniform height of five feet Only three or four lateral spurs are allowed t grow just below the point of heading back, al those below them being nipped as soon as they sprout from tim to time. The spurs thus allowed to grow form later on the mai lateral branches, and bear fruits. The shoots are periodicall pruned to encourage fruiting as described elsewhere.

Training of vines

Single-stake system

The Junnar system is named after the place Junnar, wher it was originally practised. In this case, four vines are plante in each pit. Pits are eight to ten feet apar While training them, four stakes are plante at the four corners of the pits, and a vine is trained on each o them. The heading back, growth of spurs, pruning and the lik are all similar to those of the single-stake system. The chie difference is that there is more crowding in the plantation, whic considerably hinders cultural operations and adds to the cost c cultivation. This system also requires more stakes for support.

Junnar system

In the case of the bower system, vines planted eight feet apa

·e trained on posts connected by poles crosswise at a height of .e to six feet. As in the single stake system, vines are led to the cross poles without allowing any lateral growth. They are headed back at the height of ıe cross poles, and lateral shoots are allowed to grow on them ; desired to cover the top of the frame work, making a bower. runing or trimming is done from time to time. Adjacent ıes meet one another and spread out on the bower leaving ee scope for cultural operations below.

ower system

The bower or over-head system is quite popular in all parts of ıdia, wherever grape vines are grown in bungalow compounds. he frame work is built of strong wood of good quality, and pilırs are also constructed in brick and mortar to give additional rength. Vines are allowed to ramble over this structure proiding a neat shady corner, after they have spread over the entire ower. This method of training is very expensive from the point f view of the commercial grower, but has much to recommend for the backyards of houses as it provides a fine vineyard ıvolving little labour and expense except during the first ne or two years. The vines trained on the bower also rovide a cool and delightful sitting place for the members of household.

The umbrella system consists of training vines on to a frame ork built in the shape of an umbrella. The vine rows trained by this method almost amount to bowering, except that every vine has its own bower and ; independently supported.

mbrella system

The trellis and Kniffin systems are those in which vines e trained to horizontal wires stretched one above the other at a height of two feet, four feet and six feet or so from the ground and supported on posts planted ten to fifteen feet apart in the ow. Once the vines have fully extended, regular pruning for uiting is resorted to.

rellis and niffin systems

In some parts of the Punjab, vines are headed back to a eight of two or three feet from the ground, when a few laterals are allowed to develop. In course of time the main stem gets thick and strong and can stand p erect without any support. Low headed vines raised in this ıanner save the cost of supports and are easy to be sheltered

ow-head system

from frost damage. But they are also an easy prey to jack and other pests, where such pests are common.

Relative merits of training systems

The Junnar and single stake systems were compared yield in the Ganeshkhind Fruit Experiment Station, Kirk The variety under trial was *Bhokari*. T vines trained by the single stake system yield four pounds and thirteen ounces each, wh those trained by the Junnar method yielded seven poun and five ounces of fruits per vine. But the single sta system was found to have several advantages, such as fr scope for cultivation by bullock power instead of man pow and easy irrigation. From the point of view of orchard pra tices, the single stake system, where vines are planted square is thus a superior method of training. It is cheap and mak cultivation economical. The spraying of vine is also eas Training of vines on trellis work requires a good deal of capit investment for buying posts, wires and other materials, and t cultural operations cannot be carried on crosswise. The ove head or bower system involves a large investment to start wit and it is difficult for pruning and spraying. The choice training method is, however, a matter of individual taste an resources, and under certain conditions one method may be mo remunerative or suitable than another.

Training in South India

In South India vines are trained to grow up to a heig of four to five feet from the ground without any side shoots a on the support of a live stake—*Commipho beryii*, and the canes at this height are allow to ramble over a specially erected structu made of dry wooden or bamboo poles, built at times with co siderable care and at high cost. In parts of the North-We Frontier and Baluchistan, a similar but cheaper system is pr valent, but instead of training the trunk of vines to gro erect, they are allowed to reach a small and low platfor made of dried branches, roughly at an angle of 45°. T platform is constructed between every two rows of vin at a height of two to three feet from the ground level, a canes of vines from both the adjacent rows are made to spre upon this. If more than two trunks are grown at one pla roughly half the number is made to trail their canes on t pandal (wooden structure for training grape vine) on o

side, and the rest to do so on the opposite side. Both the above systems involve an annual recurring expenditure for the construction or repair of pandal, and also render the cultivation of the vineyard by bullock power difficult, if not impossible.

The technique of training and pruning of grape vines has received a great deal of attention from American workers. The number of varieties grown in American vineyards is so numerous (30), and their varietal peculiarities regarding growth and fruiting habits are so varied, that it has been found necessary to devise the best system of training and pruning for each variety under cultivation. Bioletti (12) has shown that the training and pruning methods adopted in all systems of viticulture can be grouped under the following three heads:

Training system in U. S. A.

(a) Vase form, (b) Fan shaped or trellised,
(c) Cordon form.

As pruning methods are intimately associated with the training systems of vines, the two aspects are described together here.

In the case of vigorous growing varieties like Tokay or when vines are grown on a rich soil, the head pruning to a vase form is said to give the best results. By this method, a few spurs are retained on each vine at a height of two-and-half to three-and-half feet from the ground level. The spurs are distributed on arms all round the head, at suitable distances. Pruning to short spurs on a medium high trunk, is popular for varieties like Muscat, which bear on lower buds. For vigorous table grapes, which do not bear on short spurs, like *Malaga*, very long spurs have to be retained. For Sultanina, head pruning is recommended, but unlike in the abovementioned varieties, long canes have to be retained. Sometimes these long canes are curved to form a semi-circle when tied to the stake, while in others the canes are spread so as to present a fan-shaped head when tied to the stake. The latter method is said to be largely used for Thompson Seedless. The single vertical cordon system of training involves the growth of one trunk, around which a large number of short spurs are allowed to grow on all sides, from a low part of the trunk up to the top. In unilateral cordon, the trunk is bent at a certain height and allowed to trail over a horizontal wire or other support, and short or long spurs are distributed over the entire length of the

canes on the horizontal support. In bilateral cordons, t trunk is allowed to branch into two at a certain height, a thence allowed to trail along the horizontal supports in opposi directions. In the Kniffin system, the bilateral cordon is form on the same vine at two different heights.

Head pruning or vase or goblet pruning is perhaps t most popular method in commercial vineyards in other cou tries. The trunk in this system should be vertical, smoot straight and sufficiently high. The head should have arr starting as nearly as possible from the same level, and t number of arms should be sufficient to furnish the spurs nece sary for the production of a good number of bunches.

Since some vines are not fruitful on the lowest two or thr buds of the cane, it is necessary to adopt long cane pruning their case. Fewer canes are retained on each vine by this syste of pruning. It is necessary in this system to prune some spu to two buds, so that these may grow into bearing canes in th succeeding year. These are, therefore, called "renewal spurs.

The characteristic of cordon pruning is that the vine is given much longer trunk than in the other two systems. The trunk not vertical, but rises in a gentle curve to a certain heigh and then extends horizontally to the next vine. It is suited t vigorous varieties of table grapes, which produce large berri and large bunches.

There are numerous variations and combinations of thes three main systems of pruning and training vines. Bioletti (1 states that seedless vines are vigorous growers and need lon cane pruning and trellising. Sefick and Clark (71) observ that pruning grape vines according to the Kniffin syste was found to be the most satisfactory method in Tenness and other States. The trellis consists of two wires, 30 and inches above the ground. The pruned vine is composed of single permanent trunk extending to the top wire and a one-yea old cane trained in each direction on each wire. Summer pru ing is not recommended.

Pangara stakes

Pangara trees provide a good support in the single stake syste Large stem or limb cuttings of about six feet in length a planted near the vine on the leaward si about the commencement of the rainy seaso If it requires to be replaced, it should be done in the month

May. The top cut should be painted with liquid coal tar. *Pangara*, being a live support, should be irrigated liberally, and it grows well when once established. Special attention should be paid to the pruning of *pangara* trees, so that they remain within limits and do not outgrow the vineyard. When pruning, a tuft of leaves should always be retained at the top to nurse the *pangara* stem. Borers often take shelter under the *pangara* bark, and care should be taken to remove them and treat the trees with tar or by other means. The root system of the *pangara* is scanty, and hence this tree does not compete with the root system of the grape vine to any great extent. Pruning of *pangara* growth is usually done along with vine pruning.

Pruning of grape vines

In the Deccan, the first pruning of vine is done four months after planting, that is, in April. This is the time when the height to which the vine trunks are to grow is decided upon. A height of five feet is considered convenient. Most growers do not allow side shoots to grow from vines below this height. The present tendency amongst a few growers, however, marks a deviation from the longstanding usage. They allow the vines to grow to a height of about eight to ten feet, and encourage the growth of side shoots from about two feet above the soil. The advantage of such a method is difficult to accurately gauge at present, but it appears to be a mistake to allow such a large number of branches on the vine as they are likely to reduce the bunch size and perhaps also lower the quality of fruits. These spurs grow and form canes for the October pruning. The second pruning is given in the month of October, that is, six months after the heading back of the vines. At this time, the vine may have three to four canes growing in a head. These canes are pruned "forward", that is, leaving three or four buds at the base. Of these, one or two buds at the end sprout, and bear fruit bunches. The lower buds remain dormant. Thereafter, the vines are pruned regularly in April and in October.

The April pruning is done after the harvest is over. Canes are cut back to the foundation, and only one out of the three or four original buds is left on the canes. If any cane is weak, it is cut back without leaving any bud at all. April pruning is called "back" pruning, and is done on the same spur as was pruned in the previous October. Thus the end part of the stump

left in October, together with all new growth is pruned awa the following April. The lower bud or buds which remai dormant after the October pruning, now come to activity forms the new canes for pruning in the next October. The during the month of May induces the growth of shoots into v rous sprouts, provided irrigation facilities are available. Irri tion, however, is not given for two or three weeks after pruni depending upon the condition of soil at the time of pruni Some growers do not give any manures to the vines at the tim April pruning. But it is observed that the application of man and regular irrigation are necessary to get strong canes. growth of canes after April pruning is an important factor in ting fruiting spurs after the following October pruning, and fluences the year's crop materially.

Precautions to be taken at the time of pruning against mild and other diseases are discussed later. At the time of the A pruning, irrigation is stopped for two or three weeks to ch further growth of canes. The canes are then pruned back already explained. The soil is then ploughed deep, a hea application of manure is given, and the first irrigation is allov about three weeks after the vines are pruned. Some grow defoliate canes about three weeks before pruning, and irrig vines at the time of pruning. Experimental evidence as to benefit of defoliation and irrigation at the time of pruning lacking. It is believed that canes mature well when they are foliated and exposed to the sun, and buds develop vigorou when they are irrigated before pruning. Defoliation doubtedly facilitates pruning.

In the case of raisin grapes, three methods of pruning recognised, namely, spur (stool or short) pruning, long or c pruning, and spurring laterals on canes.

Winkler (83) states that "The retention of the larger part the yearly growth on the vine combined with some method thinning offers promise for improved quality and yield in ma table grape varieties." It is necessary to know what kind pruning is suitable for a given variety. Some varieties like Sultana produce fruits from the fourth bud from the base of cane. In this case short pruning is not desirable. This vari has a tendency to send out suckers, water sprouts and ste shoots. There is another school of thought, according to wh

A VINEYARD WITH VINES PRUNED. THE SUPPORTING TREES ARE LIVING ERITHRINA INDICA PLANTS.

Facing page 332.

GRAPE VINES SOON AFTER OCTOBER PRUNING, WITH CANE STUBS HAVING THREE

o pruning is necessary to induce vines to fruit, specially when ıey are grown for the production of ordinary wine. Unpruned ines are seen bearing good fruits in Kashmir and several other racts in India. "The main objects of pruning are to give the ines a suitable form and then to conserve this form and econdly, to regulate the bearing in such a way as to obtain he quantity of fruits for a number of years at the minimum xpense" (1). Winkler's (83) experiments on vine pruning have stablished that non-pruned vines produce more fruits and f better quality and normal sugar contents, and that pruning lecreased germination power of pollen grains.

Pruning seasons

Amongst some growers, there is a tendency to prune their ines out of the normal season, with the idea of getting fruits at a time when the normal crop is out of the market. On the whole, it is very risky to depart rom the practice of pruning in the proper season. A close study f the weather conditions in the Deccan shows that, the first two veeks of April and October give sufficiently warm weather to nduce quick sprouting of spurs. Pruning in May or June or September and November, or in months other than the usual ime, does not give a proper warmth required to induce normal prouting of buds. It is, therefore, necessary that both the April and October prunings should be practised in their proper seasons n order to get a satisfactory crop under the Deccan conditions. It is, however, found that off-season prunings may be profitable ınder certain conditions, as when the temperature is low and rains delay sprouting, as a result of which the canes do not grow properly and do not bear satisfactorily. Off-season would also be advisable when low temperature or such other factor causes njury to the vines. The frost causes injury usually in the months of January or February at the height of winter. In that case ines may be pruned in the months of February or March and llowed to grow till the end of September when they can be pruned again for the October growth. Pruning in the months of February and March under such conditions is but natural. But no crop can be expected during the usual season of November to April under such circumstances. In the Madras Presidency, particularly in the southern districts, vines can be pruned n December-January and April-June, *i.e.*, after the harvest of the crop is completed. In California, on the European con-

tinent, in the North-West Frontier Province, Baluchistan and t Punjab, pruning is done only once a year during winter or at t commencement of spring. Vines remain in a leafless and restin condition throughout winter. Due to low temperature durin winter, the disease causing organisms, like anthracnose an mildew do not thrive. Observations have been made in t Deccan to see the behaviour of canes when the April pruning dropped. Every care was taken to keep the vines free fro disease. But during the monsoon a good deal of sproutin occurred, and after the October pruning, the new spurs did n make a vigorous growth as would have been expected und normal conditions.

Girdling and nipping

Girdling is sometimes practised to induce heavy bearing i grape vines. "The process of girdling consists of making tw parallel incisions through the bark aroun either the trunks, arms or canes of the vine and of removing the bark between the tw parallel cuts. This must be thoroughly and cleanly don while the vines are in bloom" (38). Jacob (48) recommend that a complete ring of bark, $\frac{3}{16}$th of an inch to $\frac{3}{32}$t of an inch wide may be removed from the stem of Thompso Seedless and Corinth. Girdling can be practised for severa years to get successful crops, provided the soil is goo and the cultural practices are adequate. Bioletti (12 suggests that ringing should be $\frac{1}{3}$ to $\frac{1}{4}$ inch wide and shoul not penetrate the wood. It is done to increase the siz of the fruit and hasten ripening. He, however, states tha ringing is a weakening process, excepting in Black Corint (syn. Zante Currants), which hardly bears any crops withou ringing. Girdling is a necessity in the Zante Currants whic otherwise shed fruits shortly after blossoming. The trunk o these vines is girdled by removing a bark $\frac{1}{8}$ inch wid in Australia, while other vines resent such treatment, an have to be girdled on the limbs. Some writers recommen wrapping of some kind of cloth or a surgical adhesive tape roun the girdle to induce quick healing of the wound and it is als stated that "ringing affected before the flowers appear, toward the base of the branch will further increase the number o leaves and fruits". It is advised that ringing should neve be done when the clusters are partially in bloom or in th

middle of the blooming period. In case of rank growth and subsequent failure of crop, tipping of vines may be practised. It does encourage the growth of laterals. On flat soils of clayey texture, where good cultural manurial practices are followed, it has a tendency to make foliage short, close and dense with laterals at every bud down the cane length, and each has a tendency to run away, if not arrested by the knife. Ring barking can be done to obtain early ripening, and should be done when the berries are half grown. A much higher sugar content and lower acidity were observed in the ringed than in the unringed grapes.

Root exposure

After the April pruning the land is ploughed between the rows of vines and cultivated. The soil near the roots of vines is removed to a depth of about a foot in a circle with a radius of about three feet from the vines. The smaller roots are thus exposed and pruned. In about ten days the usual dose of manure is added to the original soil taken out and the whole mixture is replaced, and the roots are covered up. When new shoots spring up irrigation is given. Barnard (3) states that "Root pruning occasioned by winter ploughing to a depth of nine to ten centimeters is beneficial. The feeding roots are annual structures invariably associated with endophytic micorrhiza and are developed at a depth of five to ten inches at the base of the cultivation zone. The root growth commences about five weeks after the rise of sap begins, and three weeks after the burst of buds."

Manuring

Grape vines require heavy manuring. Generally three to five baskets of (60 to 100 lb.) farmyard manure are given in the month of April, after pruning. Oil cake, sheep dung and all such available organic manures can be usefully applied. The use of sulphate of ammonia or niciphos to a limited extent is also recommended. No manure is usually applied to vines in the Deccan after the October pruning, as it is found to encourage vegetative growth and suppress fruiting if applied. It has been estimated that a five-ton crop per acre of fresh grapes removed 33 lbs. nitrogen, 9 lb. phosphate, 27 lb. potash, 71 lb. lime and 5·60 lb. magnesia. Potash deficiency causes chlorotic mottling which later lead to scorching and collapse. Boron deficiency

in the berries becomes manifest by the appearance of brownish-green areas under the skin. Application of sulphate of potash and borax at the rate of 14-28 lb. per acre, cures the trouble in the course of two seasons (2). Farmyard manure is given at the rate of twelve to twenty tons per acre. Another fertilizer mixture recommended for grapes is :—

Sulphate of ammonia ..	150 lb.
Superphosphate (45%) ..	352 lb.
Muriate of potash ..	72 lb.
Sand	26 lb.

This mixture is applied at the rate of six pounds per vine preferably in two applications in the year. Some authors recommend green manuring in the absence of farmyard manure. In France prunings are returned to the soil which serve as a useful manure. The prunings may also be fed to livestock and enrich the soil in the form of cattle dung. Stene (74) has also found that some grape vine varieties respond very definitely to potash applications. Fertilizers poor in nitrogen and rich in potash and phosphorus should be applied especially when there exists a tendency to flower dropping. Lagatu and Maume (51) state that potash is necessary to vines, as failure to apply this in adequate amounts will cause leaf scorch, arrest of growth, yellowing of leaves and incomplete ripening of fruits. At New York, nitrogenous fertilizers have proved to be very effective in improving the yield, quality of fruit, leaf and wood growth of the vines (43). Lime had no appreciable effect on vines, while phosphoric acid and potash had so small a beneficial effect that their use was not profitable. Stable manure and green manure did not yield any consistent or conclusive results.

In Malta (14) vines are manured every third or fourth year. Shallow trenches are dug fifteen to twenty centimeters deep and farmyard manure at the rate of half to one basket per vine is put in them. It is reported that "excessive use of organic manures will produce grapes of inferior quality for the wine press."

The best manure for grapes, however, seems to be the stable manure which supplies organic matter or humus and is complete with most ingredients. Ten tons of stable manure applied

ery third year may suffice to maintain the fertility of the soil. able manure is scarce and hence artificial manures, supplemented with green manure are applied. Vines over-supplied ith nitrogen produce delicate shoots that are liable to fungus tack. While nitrogen promotes growth of cane and leaves, osphoric acid gives tone to the vines and improves the quality fruits. Either of the following manure treatments may be lopted with advantage in Bombay Presidency:—

(1)	Bone meal	1 cwt.
	Sulphate of potash ..	1 cwt.
	Sulphate of ammonia or nitrate of soda	1 cwt.
	or	
(2)	Bone meal	1 cwt.
	Blood manure	2 cwt.

hese doses are meant for one acre. Vines may be manured in ombay Presidency once in April and again in the winter, when unches are formed. The manure should be applied in furrows x to eight inches deep on either side of vines and two feet away om them. The winter application would help the development of bunches and improve their quality, while manuring the ines at the time of April pruning is desirable to stimulate rowth of the plant.

rigation

Grape vines require regular irrigation in the Deccan. Irriation is given to them almost throughout the year, except for a few weeks at the time of April and October prunings, and during the monsoon, when ater is applied only if there is a break in the rains. Without certaining that a sufficient supply of water will be available the wells throughout the year, it is unwise to go in for neyards. The summer months during which scarcity of ater is felt in many parts of the Deccan is just the period hen irrigation is required for this crop to foster the new owth after the April pruning. If the wells fail to ve an ample supply of water at that time, the vines ay be seriously damaged. Regular irrigation is also essential om October to March, which is the fruit bearing period. The ethod of irrigation common in these tracts is the flat bed or

round basin around each vine. But owing to the close plant and heavy irrigation applied, the system actually amounts flooding. Flooding is unavoidable, because the soils are d black and heavy, generally deficient in humus, and have a t dency to crack and dry up near the surface after each irrigati Consequently, frequent irrigation and stirring the surface soil necessary. Watering is given once in six to eight days during fruting season. It may be noted here that the first water after October pruning is sparing, just enough to wet the surf soil. The quantity is gradually increased to the full dose the third or fourth turn. Heavy irrigation in the beginning courages vegetative growth and is likely to suppress fruiti De Castella (17) states that "The usual practice of giving heavy irrigation when vines are in full bloom in summ tends to produce excessive vegetative growth at the expense of fruit." He suggests that under Australian conditions, af giving copious irrigation in August, the next irrigation can given in November. Frequent irrigations are of course nec sary during the summer, the first irrigation commenci when the buds are about to burst.

Thinning of bunches

In the Deccan, grape vines bear bunches chiefly after t October pruning. These bunches develop sweetness and quali producing a marketable crop. After the Ap pruning also, the vines bear some bunch which, if allowed develop and mature duri the monsoon. Such fruits become sour and unmarketable, sin they do not seem to be able to synthesize sugar sufficient at th period of the year. It is, therefore, the practice to pick off blossoms which appear after the April pruning, in order to co serve the energy of vines for the October crop. No thinning bunches is practised in the Deccan in the case of the Octol crop. Knapp (50) while emphasizing the value of clean a careful cultivation in the vineyard, advocates keeping t bunches clean. In the case of loose or straggling clusters set of shot berries or both, thinning of flower clusters is commended by Winkler (83), who also recommends be thinning, when they are too dense in the clusters, in order improve quality.

It has already been mentioned that frequently grape vi get damaged by low temperatures in the Nasik area. It

ɔscrved that when the temperature falls to 35° F, the foliage ıd tender parts of canes are altogether killed. Whenever

ıjury due to frost

low temperature is accompanied by strong wind, the damage is sudden and severe. 'ell-protected portions of vineyards, sometimes escape damage. sually the lowest temperature is recorded between 3 a.m. ıd 8 a.m., when frost occurs. At present, no successful eatments to protect vines from frost or low temperatures have ɛen discovered in the Deccan. Covering the vineyards is expen- ve. Burning of firewood in and around them and flooding are ɔt efficient enough in the fight against frost. Observations ıow that burning wood and flooding do not raise the tempera- ıre of the field appreciably. It is noticed that there is a rise of ıly one or two degrees in fields where such methods are em- .oyed as compared with the temperature outside. Heating of ·chards, as is done in California, has not been tried in ıis country on a large scale, due to the high cost of such methods. : may be possible to raise the temperature by five degrees ahreinheit by using modern heaters. But this requires about ıe hundred heaters per acre and the cost of burning them for ıur or five hours may go to Rs. 150/- to Rs. 200/- per night.

When frost damages the crop, the temperature near the sur- ıce of soil is usually 24°F to 26°F, and the atmospheric tempera- ıre under shade is 31°F to 33°F. The Bombay Department of .griculture has arranged to get timely intimation from the Me- :orological Department when frost is expected in grape reas, and to send it to important centres by telegrams. But e benefits of such a service cannot be fully availed of by ·owers for want of proper means to fight against the adverse eather. In the year 1936, some preliminary experiments on e protection of grape vines from frost were conducted at Nasik. ıe observations included the effect of wind-breaks, oil heaters ıd fire wood burning. The tentative conclusions were that ind-breaks gave a temperature rise of two or three degrees ıhrenheit, modern oil heaters at the rate of two hundred per ·re and country heaters gave a rise of six to seven degrees ıhrenheit only at a cost of Rs. 75 per night.

Cold waves are not known to do much harm to vineyards in nd and North-West Frontier, as in those tracts the blossom ɔpears in the months of February and March, when there is little

likelihood of the occurrence of low temperature. Furthe the existence of severe winter conditions during Decemb and January force the vines to dormancy.

Improvement of grapes by raising seedlings

Effort has been made to improve the quality of *Bhoka* which is the most important commercial variety of grapes in t Deccan, by raising seedlings of this variety a making selections from them. Out of a lar number of seedling vines raised and rear to fruiting, some produced fruits of bett quality than *Bhokari*. But it has to be seen yet wheth these selected seedlings are also high yielders. Seedling No. 9 appears to be promising. The main features of this seedli are:—

> Vine growth fairly vigorous, stem brown, cylindrica glabrous, young growth smooth, internodes short, te drils more frequent, occurring practically at every node leaves membranous, basal lobe overlapping only in th advanced stages; clusters occur opposite the fifth leaf, t bunch is long and compact, berries oblong and fairl well-developed; colour yellowish tinged with gree pulp soft and melting; taste mild acid. It is good fo table purposes.

It appears possible to develop strains or varieties, which are la or early, and which are resistant to diseases by pursuing breedin work further. Grape selections that have recently been mad in certain countries for the resistance to the attack of certai diseases show that, certain strains are satisfactory. Observatio on resistance to cryptogamic diseases made in one count may not, however, be applicable to another. Fennel (3 describes his search for suitable species in south of Florid and his hybridization experiments. Some 100,000 seeds we sown, and thousands of seedlings have already been plant out. The new varieties which would be evolved may be mo adaptable to tropical conditions than those raised from speci of temperate regions.

Dearing (30) reports that the native vines and muscadi grapes, have been greatly improved by crossing and sele tion. One of the most striking results has been the creati of self-pollinating kinds with complete hermaphrodite flowe

Improvement of grape vines by bud selection has be

attempted and several types are reported to have been selected as bud sports and propagated true to type.

Sterility in grapes

Sterility is marked in grapes and due to this phenomenon, there are a number of grapes which are seedless. The *Pandhari Sahebi* is practically self-sterile and shy bearing. When grown side by side with *Bhokari* it bears better crop and produces uniform berries due to fertilization with the pollens of *Bhokari* (31). Roussopoulos (69) mentions that optimum climatic conditions combined with heavy manuring encourages the development of seeds in seedless types. Stout (75) reports that "Varieties like the Bright Lindley, Baty and Massasoit, have curved instead of erect stamens, and the stamens are more or less aborted and have shrivelled and defective pollen grains. Self-fertilisation in these types is rare, and intervention of foreign pollen is necessary." He adds that "There is a group of grape varieties which produce pipless or almost pipless grapes. . ."

Food value

As in other fruits, varieties of grapes differ in their food value. As a rule grapes are stated to be a fair source of calcium, phosphorous and iron. Some varieties like Concord and Isabella, were found to be poor sources of vitamins A and B, while C and G vitamins were entirely absent in them when tested without skin. Sultanina and Malaga grapes with skin on the other hand showed small quantities of vitamin A, fair amounts of vitamin B, little or none of vitamin G, and very little of vitamin C. Commercial grape juice is reported to have no vitamins at all. (Also see pages 342 and 343.)

According to Winton and Winton (85), grapes (American) contain 22·60% total solids, 1·3% protein and 0·5% total ash.

Sherman (72), on analysis found the composition of American and European grapes as follows:—

Edible Portion	American grapes.	European grapes.
Water	81·9%	81·6%
Protein (N × 6·25)	1·4%	0·8%
Fat	1·4%	0·4%
Carbohydrate including fibre	14·9%	16·7%
Ash	0·45%	0·46%
Fuel value per 100 gms.	78 cal.	74 cal.
Fuel value per lb.	355 cal.	355 cal.

Quantitative data of Vitamin content of grapes are reported to be as follows by Daniel and Munsell (27).

	Vit. A	Vit. B	Vit. C	Vit. D	Vit. G
Grape (*Vitis* spp).					
Concord	66	—	—	—	—
Malaya	21	11-13	6	—	0
Thompson Seedless (Sultana) ..	50 (Int)	33	3	—	—
Tokay	50	—	—	—	—
Frozen (Thompson Seedless) ..	25 (Int)	12	Gradual loss	—	—
Raisin (Thompson Seedless) soda dipped, sulphured, dehydrated	178 (Int)	0	0	0	50

Int. means International Units and others denote Sherman Units.

Work done in India shows the following analysis of grapes:

Name of food	Botanical name	Moisture %	Protein %	Fat (Ether Extraction) %	Mineral Matter %	Fibre %	Carbohydrate %	Calcium (Ca) %	Phosphorous (P) %	Iron (Fe)mgs %	Calorific Value per 100 gms.	Carotene (Int. Vitamin A unit per 100 gms.)	Vitamin B (Int. per 100 gms.)	Vitamin C (mgs. per 100 gms.)	Calories per ounce.
Grapes (Blue variety).	*Vitis vinifera.*	85·5	0·8	0·1	0·4	3·0	10·2	0·03	0·02	0·4	45	15	Trace	3	13

A great deal of damage is done to the vineyard in th Deccan both by the powdery and downy mildews.

Diseases and pests

Powdery mildew is caused by *Uncinula necator* and the down mildew by *Plasmopara viticola.* The first signs of downy milde are seen on the leaves as greenish yellov more or less circular spots known as "o spots", which appear more transparent than the normal tissu when the leaves are held against light. In moist war weather, the glistening downy mildew makes its appearanc on the under surface of leaves and can be easily scrape off. The affected spots ultimately turn brown, dr up and crack. Downy mildew also attacks young bunche causing them to dry and fall off. Affected shoots are dwarfe and they may die. The fungus, however, cannot attack rip wood of vines. Affected berries become hard and finally shrive into mummies. Powdery mildew appears first as whitish patche later turning greyish white on both the surfaces of leaves. Th spots do not turn brown as in the other case. The mottle appearance of the leaves attacked by powdery mildew is differen from the more or less well demarcated spots of downy mildew o the leaves. When the blossom is affected with powdery mildev it fails to set fruits. When young berries are affected, they d not ripen. If attacked when half grown, the fruits crack and ar disfigured by spots. The cane is also affected. The following i the programme of treatment of the two mildews:—

1. Prune vines in the first fortnight of October, as thos pruned early in September are open to the seriou attack by downy mildew, whilst those pruned lat in October or early November do not sprout well.
2. Apply Bordeaux mixture (3: 3: 50) when shoots ar three or four inches long, followed by another appl cation after a fortnight or so. If the weather con tinues dry after the second application, there wi be no need for the third application. Howeve if late heavy rains are received in November a thir application of Bordeaux mixture will be beneficia but it must be made before flowering, as it cause damage to young flowers.
3. During flowering, apply sulphur dust at the rate of te

SPRAYING BORDEAUX MIXTURE ON GRAPE VINES WITH A BUCKET SPRAYER.

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to twelve pounds per acre. Sulphur dusting at the time of flowering is extremely beneficial as it helps setting of berries.

4. The second application of sulphur dust should be made about a month after the first dusting, and the quantity of dust used at this time should not exceed ten pounds.
5. The hot weather (April) pruning should be done about the first of April, so that the vines can have their canes properly matured, before monsoon sets in in June. It is desirable to spray vines early in June with Bordeaux mixture (5: 5: 50). Failure to spray vines before the rains, may result in the shedding of leaves in September, and the early sprouting of buds due to mildew attack.

' this programme of treatment is carefully followed, the ines can be kept almost free from mildews. Bordeaux mixture perhaps the most common fungicide in use. It is used in ifferent strengths as may be needed by the seriousness of attack, ıd the nature of the causal organism. For a normal solution, ve pounds of copper sulphate, five pounds of quick lime and fty gallons of water are taken. The copper sulphate is dissolved in four gallons of hot water in a wooden tub or an earthenware vessel. No ıetal vessel should be used for copper sulphate solution, as the ıemical acts on the metal. To the above solution cold water added to make it up to ten gallons and stirred. In another ssel, five pounds of best quick lime is slaked and then enough ater is added to it to make up to ten gallons. The copper lphate solution is then poured slowly into the lime suspension, ınstantly stirring the mixture. Bordeaux mixture is then ady for spraying, on the addition of the remaining amount of ater to make up the whole to fifty gallons. Bordeaux mixture ould be properly prepared so as to have no free copper sulıate in it. This is tested by immersing a clean blade of a steel ife in it. If a reddish deposit is seen on the blade, then more ne water should be added to the mixture, and stirred, until e knife blade remains clean on dipping.

ordeaux mixture

Anthracnose is caused by the fungus *Gloeosporium ampeɔhagum* which produces cankers or scars on leaves and

shoots. The scars appear at first as small brown spots, whic enlarge and become depressed in the centr Affected blossoms appear as if charred.

Anthracnose

The well-known "bird's eye spots" are produced by depre sions on berries. The central portion of the spots is gr and somewhat depressed and is surrounded by a circular re purple zone. Moisture in the form of rain or dew drops necessary for the germination of anthracnose spores and infectio for the vines. Low temperatures favour the development anthracnose which is a slow spreading disease, and does n devastate the crop with such rapidity as downy mildew does.

The disease can be controlled by spraying with Bordea mixture (5: 5: 50). On pruning, all the branches are cleane and the stem is sprayed with Bordeaux mixture. In seve cases Bordeaux paste which is but a concentrated preparatio of Bordeaux mixture, being in the proportion of 1·5 lb.: 1·5 lb 10 lb. is smeared on vine stems, after pruning.

The only severe insect pest of vines in the Deccan is *Scel donta strigicollis* M. which is locally known as *Udadya*. It ea up the tender growth of spurs. The colour this beetle is dark brown black with brig bronzy reflection. The beetles feed on growing shoots an leaves and damage the vines considerably. The larval an pupal stages are passed in the soil. Mechanical control very effective by (1) removing bark of the vines to avoid eg laying ; (2) trapping the adults in six to nine inches in lengt *Tassels* formed of banana leaves placed on the pruned en of vines near the sprouting buds, where the insects tak shelter in these bundles and are shaken of at intervals in vessel containing kerosene and water; (3) the most effective wa is the "Umbrella" method of passing an inverted umbre under the vines and collecting the beetles in that by shakin the vines. The beetles are then collected in gunny ba painted inside with coal tar. The use of Bordeaux mixtu and calcium arsenate is recommended in Madras.

Insect pests

There is another type of beetle (*Adoretus ovalis*) seen attac ing grape vines at Nasik. This pest appears in Novemb Hand-picking of these insects is recommend Dead wood on vines in which they hide shou be removed and burnt to remove all shelter to these pests. T

Cockchafers

PEERLESS DUST GUN AT WORK DUSTING GRAPE VINES WITH SULPHUR POWDER AGAINST POWDERY MILDEW.

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EARTHEN POT USED FOR PACKING GRAPES WITH SAW-DUST AS PACKING MATERIAL IN AHMEDNAGAR DISTRICT. THIS IS BEING DISPLACED BY BAMBOO BASKETS.

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ommon practice in the grape-growing districts of the Deccan is o peel off all dead and dry bark of vines, thus cleaning them oon after pruning is done. In vineyards which are not cleaned n this way from time to time and in which the vines possess nany unclean knots, the pests do great harm to the crop.

Thrips

Rhipiphorothrips Cruentatus H. are minor pests but in case of severe infestation the shoots may wither away. Spraying with Nicotin Sulphate or tobacco decoction is quite effective.

Harvesting

Different varieties of grapes develop different hues on their ounches, when the berries are ripe. The *Bhokari* develops a pinkish colour on the berries when they are fully ripe. The bunches are usually eady for picking when the peduncle gets somewhat shrivelled, nd the characteristic hue is fully developed. In the Deccan, rape bunches are harvested by hand. Picking is done a ew days earlier when bunches are meant for distant markets. There is no systematic observation made on the right stage f ripening of grapes in this tract. But it is best to harvest rapes, when they are fully ripe on the vines. In America, he harvested bunches are allowed to wilt in the packing ouse until the stems are perfectly dry. Bagging of bunches vith thin manilla sacks is also done as a protection against nsect attacks. The bags are usually provided with two or three mall holes in the bottom to drain out the water that may nter them. Bioletti (9) states that berries of young vines ripen uicker than those of old vines. He also states that berries exosed to the south ripen earlier than those to the north. Bunches t the base of the stem ripen earlier than those at the top.

Marketing of grapes

The method of packing, marketing and transporting f this delicate fruit in India requires a good deal of improvement. At present the fruit is packed in ten-pound bamboo baskets, with grape eaves or dry grass as packing or padding material. Grapes rom Ahmednagar and parts of Southern India are packed n earthen pots, holding about twenty to twenty-five pounds ach, with or without saw dust for packing. The earthen ots locally called *madkis*, are carefully handled in transit y the railwaymen for fear of breakage, and hence the fruits nside them are not damaged much. The baskets from Nasik

are principally sent to the Bombay market by railway, and sol by the commission agents at the current market rates. Th commission agents charge either one anna per rupee or fou annas per package as their agency commission. No specia care is taken to pick bunches at the proper stage of maturity This lowers their value in the market. Besides, some c the bunches are damaged in transit also. Such condition coupled with irregular methods of sale in the market wor adversely on the economics of grape cultivation. The Baluchis tan (Chaman) grapes are brought to the markets of Bombay i willow baskets of forty pounds capacity packed in grass an carried in refrigerated vans. The fruit is sold in the market b auction sale and not by the "secret treaty" method common i the case of other fruits. For long distance markets like Calcutt and Madras, grapes are packed in wooden boxes. Grapes c good quality come to the Bombay market from Italy and Spai also. They are packed with cork dust in wooden barrels. Th fruit is shipped under refrigerated conditions. These grape fetch a good price.

In France, the picking of grapes is standardised, the stan dards differing for different varieties. Trays of varying dimen sions are used for packing grapes.

The methods of grape storing by packing the fruit amon layers of cork is only applicable to certain varieties. Som

Storage

grape varieties can be easily preserved a they are grown in extremely dry climat which increases the percentage of sugar in the berries. Som types of grapes keep for a long time, if cut and placec in layers on saw dust in receptacles, but will not keep wel if left hanging on vines. White saw dust, a mixture of fi and spruce, showed much better results as a packing materia for grapes than red-wood saw dust or cork at 32°F. Th optimum range of storage temperature for grapes of severa varieties is said to be 28°F to 32°F (80). The storage life ma vary from two to six months according to varietal and environ mental factors under the best storage conditions. Accordin to Reyneke and Du Plessis (68), S. African grapes are ver susceptible to damage from sulphur dioxide fumigation, but i certain trials, when fumigated with 0·25% to 0·3% SO_2, they hav survived in exceptionally good condition. High temperatur

luring SO_2 fumigation also materially increase damage. Spraying he packing material at the bottom of the grapes with 20 cc. of a olution containing 20 g. potassium or sodium bisulphite in 00 cc. water per 10 lb. box (*i.e.*, 1 tablespoonful per box) esulted in the grapes maintaining their freshness and attraciveness in comparison with untreated boxes in which much of he fruit rotted. They further add that the S. African conumer prefers a well-coloured grape with a high sugar content ınd if possible, unusual flavour.

For inland distribution the most suitable transport temperaure is 60 degrees F and facilities to maintain this temperature on rail are very desirable and should cost less than the cooling of insulated cars to 40 degrees F by means of ice as is now done (34).

Economics of grape cultivation

It is calculated that the total receipts per acre from grape vines might go to Rs. 1,500 or more.* But it costs about Rs. 1,000 per acre to maintain the vineyard and to cultivate it well. The net profit per acre is, therefore, about Rs. 500. This is of course exceptional and these figures are rarely reached under normal conditions. The net profit of Rs. 500 appears to be an attractive figure. But if, once in three or four years as it happens in the Deccan at present, the crop is damaged by frost, the whole profit is wiped out. Hence, of late, grape cultivation has become a fairly risky undertaking in the Nasik district. However, heaters and other precautionary measures against frost are being commonly adopted. In the Madura District of Madras Presidency, an amazingly high yield of about 25000 lbs of the ocal green grape is claimed by some growers, while Kishmish, he seedless variety of Baluchistan is reported to yield about 15000 lbs. per acre per year.

Drying of grapes

The conditions for drying grapes are not very suitable n the Deccan. The percentage of sugar in the Deccan grapes is very low. Besides, incidental showers in the month of April cause a good deal of lamage to the fruit in the process of drying. Some enterprising growers, however, have dried their *Bhokari* grapes for trial.

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*The figures prevailed in the' thirties. During and after World War II, the cost and income figures have risen even three to four times.

Although the product obtained was not of a superior quali grape drying appears to develop into a useful side industry wh fresh fruits do not fetch a good price in the market. Ot varieties were not tried for their drying quality. Moreov their production is low, and there is usually little fr available for drying. Well washed grapes are dipped lukewarm lye solution for just a minute or two and th thoroughly rinsed in cold running water. They are th exposed to sulphur fumes in a sulphur box for one hour and th either dried on wooden trays in the sun under dust-proof con tions as far as possible or dehydrated in the home-drier at a te perature of 160°F. The dried raisins are then graded and pack in air-tight paper-lined wooden cases.

In 1913, most of the world's raisin production was report to be restricted to California, Turkey, Spain and Australi Muscats, Sultanas and Currants are the three most importa varieties used for raisin manufacture. The seedless raisi are made mainly from Sultana, Sultanina, Black Corin and White Corinth. The method of preparing raisins described by Cruess, Christie and Flossfedef (24). The fru are dipped first in a boiling solution of half to one per cent l (sodium hydroxide) for three to five seconds. Some varieti like Muscat and Malaga require two to three per cent l solution for satisfactory results, and the time of dipping m last upto fifty seconds. Dipping in lye imparts a glossy appea ance, facilitates evaporation and renders the raisins sweete Special dips containing olive oil, glycerine or mineral oils appe to improve the colour and keeping quality of raisins. T dipped grapes are rinsed in fresh water and then dried sun or in evaporators. Twenty to thirty-three days a required for drying undipped grapes while dipping reduces t time by about one-third to half. Some grapes are fumigat with sulphur fumes before drying. Sultanina requires fumig tion for half an hour, while red wine grapes that are to sun-dried require to be exposed to sulphur fumes for one hou Solid bottom trays are preferred for drying operation. T evaporated grapes have to be kept in sweat boxes or bins for o or two weeks to permit equalisation of moisture in the raisin It is said that grapes dried to twenty-four per cent or twenty-fi per cent moisture will keep well under California conditio

Some varieties have to be subjected to the process of seeding (removal of seeds) after drying.

Late picked grapes may sometimes be dried in chambers at a temperature of 160° F. In California, it was observed, that the drying ratio is regulated by the sugar content. To obtain raisins of first quality, Muscat grapes should not be picked when their juice reads below 25 degrees Balling, nor Sultanas below 23 degrees (Balling indicating sugar content). Raisins are prepared on a large scale in California. Currant grapes are dried on a large scale in Greece. Sultana is dried in Asia Minor. Monuka is a special dried grape of Afghanistan. In Baluchistan and North-West Frontier, grapes are dried entirely in the sun. But some preliminary trials conducted in this country several years ago, showed that good raisins can be prepared by adopting the American method of evaporation using a small dehydrator of the type described elsewhere for drying figs and banana.

Ciferri (23) states that in the province of Macerata in Italy, it is the custom to keep fresh grapes for domestic consumption. The bunches of ripe grapes are hung up in a cool place preferably in a well-ventilated cellar. Thus stored, grapes keep for a long time, though they shrivel and assume a colour varying from amber to brownish yellow, having in short the characters of dried grapes. Dried grapes are liable to the attack of *Macrophoma flaccida* along with mildew.

Unfermented grape juice has been used as a popular beverage for centuries in many parts of the world. For bottling fresh grape

Bottling of grape juice

juice, it is very necessary that the fruit should be juicy and aromatic, so that the juice can have its "character." Taking this into consideration, Black Prince is perhaps the only type in the Deccan, the juice of which can be satisfactorily bottled. Grape juice is being canned in the United States of America on a fairly large scale. Bottling grape juice is not a very elaborate process. The fruit is pressed, and the juice on being collected is mixed with "German soil" and heated to 65°C and filtered. This filtered juice is then bottled, and pasteurised at simmering temperature (80°C) for twenty to thirty minutes, closed air-tight while still hot and stored. In the case of coloured grapes, a little juice is added to the pomace, which is treated to a temperature of 160-165° F in order to extract the colour. It is then pressed

and the extract filtered and mixed with the bulk of the juic to be bottled. Bottled juice of most varieties of grapes leave a thick sediment of tartrates, when stored for some time. I such cases, it is necessary to open the bottles after a few month of storage, syphon off the clear liquid, bottle it again and pas teurize as described above. There does not seem to be muc demand for fresh or bottled grape juice in the Indian market where sufficient taste is not yet created to develop bottling of grap juice into an industry. But a limited sale of juice is pos sible if it is properly bottled and packed. Grapes furnish a larg variety of products such as wines and syrups (15). Jelly an conserves can also be prepared from them, while in Franc and along the Mediterranean coast choice wines are manufac tured out of grapes. The manufacture of syrups is easy an can be followed on the lines of fig or any other fruit syrup.

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CHAPTER VIII

SAPOTA OR *CHIKU* (*Achras sapota* L.)

ntroduction

Sapota is a popular fruit in most parts of India, though not very great commercial importance except in a few regions. It is known by a number of names in different parts of the world, such as *chiku* (or *chico*) in ombay Presidency, bully tree, *ratami* and *shimai-eluppai* in eylon and extreme South of India, naseberry in West Indies nd sapodilla or sapote in several other parts of the world. s scientific name, *Achras sapota* is sometimes confused with *chras zapota* L. The latter is popularly known in America as apote or mammey sapote, both of which terms closely resemble e common name of sapota applied to the former. Both the uits belong to the family *Sapotaceae* and are classified under the roup of tropical fruits.

In India, the *chiku* is the only kind that is of any importance. t is grown in this country solely for its fruits. The following istinguishing characters of other similar fruits are given in rder to avoid the possible confusion that may arise owing the close resemblance of the popular names. The sapote r mammey sapote is an erect growing tree with large aves resembling in outline that of loquat (*Eriobotrya japonica*). Thile the leaves of sapota are smaller, leathery, very thick and ark green or shining green in colour, those of the mammey apote are shining light green above, and light brown beneath. he latter are ovate to elliptic in form, while those t' ovate or peach or apple-shaped. a nut-brown colour and a e the mammey sapote arm pulp of a reddish a fruit, and this is ordi- colour, hard, smooth and everal shining black smooth borne severally in the axils

There is still another fruit, which bears a similarity in name the *chiku*. This fruit is designated in California as white sapo (*Casimiroa edulis*) and is grown extensively in Mexico ar to a small extent in southern California. It belongs to t family *Rutaceae* to which the citrus fruits belong. The fruit white sapote resembles a quince in shape and has a soft and ve sweet pulp, tinged with a slight bitterness. The skin of t fruit is smooth, green to yellowish green in colour, som times with a dash of bright orange or yellow. The leav are palmate, and dark green in colour. Unlike the whi sapote and the sapote, the *chiku* is grown both for fruit well as for the manufacture of chewing gum in America. yields a white latex from which chicle used in the man facture of chewing gum is obtained. The green sapote (*Lucun viride*) and the yellow sapote (*lucuma salicifolia*) are oth plants which are likely to be confused with that of *chik* The green sapote tree resembles the sapote in gener appearance and habit, while the yellow sapote is a small tr bearing a slender orange yellow fruit. Neither of the tw varieties are grown in Indian orchards.

Origin and distribution

The original homeof *chiku* trees is the Tropical regions South America. Its cultivation is extensive in Mexico ar neighbouring countries. It has now sprea to other Tropical countries, including Centr America, South of Florida, Ceylon, Jamaic and Philippines, where it has merited some attention. In Ind the cultivation of *chiku* is concentrated in the plains of th United Provinces, Bihar, Madras Presidency and Bengal and o the Western coast of the Bombay Presidency, especially in th districts of Surat, Thana and Kolaba. Some large old *chik* trees are said to be growing in parts of Jamnagar, Junagadh ar Gondal states in Kathiawar. Of late, it is slowly spreading other parts of Western India like Poona, Nasik, Ahmednagar ar Bijapur districts. In South India, the Vizagapatam distri is the leading chiku growing centre. The district of Navsari the Baroda State has a good deal of *chiku* cultivation which extending further. The tract lying between Bombay ar Surat in particular seems to offer the most suitable conditio of soil and climate for the growth of *chiku* trees, so much that the cultivators of this tract have specialised in its cultiv

n. In the Bombay market, the *chiku* fruits of this tract are iowned and they command a high price due to their superior ality. These trees were first introduced into this tract in about : year 1898 at Gholwad, a small village about seventy miles to : north of Bombay. *Chiku* was then grown in the vicinity Bombay, as a rare and costly fruit plant. It has since then y speedily spread to Dahanu, Gholwad, Umbergaon and the ghbouring places. The total cultivation of *chiku* now extends er an area of 2,000 acres in this tract. It is fast increasing ause of the hardy nature of the trees, profuse bearing, freedom m any serious pests and diseases and availability of fruits nost throughout the year.

rieties

The varieties of *chiku* remain yet to be properly studied and ssified. Commonly, two chief types of fruits are recognised in Bombay market one has round fruits and the other oval es. But fruits of both shapes are found on the same trees at same time or in different seasons of the year. Seasonal changes are said to influence the shape of fruits considerably. There is, however, a great varia- n in the branching habit, foliage and bearing of trees, as l as in the texture of the skin and colour and shape of fruits. few of these characters seem to be correlated. The trees stly present a great predominance of certain characters in ference to others. On this basis, an attempt is made here to up sapota trees as follows:—

(1) Tree habit erect; branching in whorls; foliage deep green; leaves broad oval; fruits large with smooth yellowish skin; pulp sweet and butterlike.

(2) Tree habit drooping; branching in whorl; the foliage light green; leaves narrow elliptical; fruits small with rough brownish skin; pulp inferior in taste.

(3) Tree habit spreading; branching irregular; foliage deep green; leaves broad oval; fruits with smooth yellowish skin; pulp sweet and butterlike.

(4) Tree habit spreading; branching irregular; foliage light green; leaves narrow elliptical; fruits small with rough skin; pulp inferior.

Each of these groups may further be subdivided into two ions depending upon the shape of fruits, which may either be efly round or oval.

Some trees have fruits with pointed ends, and resemble t playing top. Others have predominantly egg-shaped frui Generally, large fruits seem to be associated with broad ov leaves. Small and inferior fruits go with narrow long leav In the Surat and Navsari districts, the following distincti varieties are recognised, of which the first three alone are e tensively grown:—

(1) *Kali.* Leaves broad, thick and green in colour; fru borne in singles; fruit quality high; main pickir season winter; fifty per cent gooties of this varie strike roots.

(2) *Dhola diwani.* Leaves light in colour; fruits whiti and oval in shape; fruits superior in quality to Ka main picking season early summer months; gooti strike roots easily on the tree.

(3) *Large Calcutta.* Leaves light in colour; fruits fifty p cent larger than those of other varieties; gooti difficult to strike roots; grafted on *rayan* (*Mimuso hexandra*).

(4) *Long.* Leaves narrow and small, looking longish shape; gooties strike roots very easily; fruit thin ar long and very sweet in taste; bearing very poor ar hence not commercially paying.

(5) *Bhuri.* Foliage thick; leaves medium sized; bearir medium; fruits large and of high quality; tr shapely.

(6) *Jingar.* Tree medium; leaves small; fruits very sma fruits borne in bunches; gooties strike roots easily

(7) *Vanjet.* This is a sterile or male type. Tree gro slowly and produces knots on the branches; oft roots emerge from these knots; bearing very sh fruits are good to eat; gooties strike roots easily.

Round about Vizianagram in the Madras Presidency sapo cultivation has received a good deal of attention in recent yea Over a dozen varieties are recognised there, the most importa of which are listed below:—

(1) *Kittubarti.* Very small egg-shaped fruit, with four six ridges on the rind; skin is rough, medium th and has a buff colour; taste very sweet when fu ripe. There is also a variety called Kittubarti b

which bears big hard fruits suitable for long transport, but inferior in quality to small-fruited varieties.

(2) *Bangalore*. Large sized oval fruits, with about nine ridges running from the base to the apex; apex round as compared with the slightly tapering form of *Kittubarti*, flesh gold coloured with musk melon tinge towards the core; medium sweet.

(3) *Jonnavalosa I*. Medium sized fruit, similar in shape to 2, but less broad at the sides; skin rough, thin, with no ridges; cream coloured flesh near the skin; but assumes a pinkish tinge towards the core; sweet.

(4) *Jonnavalosa II*. Medium sized fruit, ovate, has a prominent depression near the stalk end, skin buff coloured, with whitish flakes and eight marked ridges; flesh musk melon coloured with golden tinge near the cavity. Sweet, but has a rather unpleasant flavour.

(5) *Pot Sapota*. Small sized fruit, oval with a pointed apex, ridges absent, thin skin and walnut coloured flesh, very sweet with agreeable flavour; bears fruits even when grown in pots; hence the name.

(6) *Gauranga*. Small sized fruit, ovate, with, one shoulder drooping and the other raised. Eight to ten marked ridges; flesh soft, melting and very sweet.

(7) *Thagarampudi*. Medium sized fruit, round to oval with a flat base; skin rough but thin; no ridges; flesh buff coloured, melting, juicy and streaked, very sweet. Even when picked green, fruits ripen well, unlike in other varieties. Good for export.

(8) *Ayyangar*. Large sized fruit, round to obovate with a slight cavity at the stalk end; ridges not prominent; skin very thick and buff coloured; flesh has pinkish tinge towards the core, rose scented, sweet and with pleasant flavour.

(9) *Bombay*. This variety bears both round and oval fruits of different sizes and is perhaps identical to those grown in Bombay, Bihar and Bengal.

(10) *Dwarapudi*. Largest sized fruit, round, sweet and much in demand.

(11) *Cricket Ball Sapota*. This is grown at Coimbatore and

on the lower foot of the Nilgiris. Fruits of ve large size, round, very sweet, but not of any distin tive flavour.

(12) *Jonnavalosa Round.* Large sized fruits, shape near round, but sometimes obovate, and oval fruits a also met with; small cavity present at the stalk en ten to eleven ridges; cream coloured and firm flesh very sweet.

The above nomenclature is not accepted as standard although th distinctive characters of the different varieties are recognise On the West coast of South India, all the varieties are classed int three groups, namely, the round, the oval and the large size In the United Provinces a variety known as the Plum Sapota grown around Saharanpur. Most of the characters mentione above as distinctive of the various varieties are more or les superficial and highly variable. As in the case of several othe Indian fruits, so in *chiku* the proper study and classification an urgent need to regulate its economic extension. A grea headway has yet to be made in standardising these varietal name The existing grouping is often confusing and indefinite.

Soil

Chiku trees are seen growing on a variety of soils, includin the most porous sandy soil of Gholwad and the medium black so of Kopergaon (Rahata). But a well-drained deep and porou soil, like that of Gholwad, Dahanu and Gandevi (Baroda State) is specially suited to their proper growth. A layer of hard murum at a depth of two to thre feet from the surface is harmful to the luxuriant growth of th trees as well as to their profuse bearing. In such soils the tree grow well for a period of about eight years, and when the root strike the murum layer below, the growth of the trees is arreste the foliage turns pale, and the bearing as well as the size o fruits diminish. Examples of this phenomenon are seen at Gho wad and other places. In soils which form a hard cake at th surface after the rains, the branches of *chiku* trees wither, ulti mately leading to the death of the trees. In very loose soils, stron winds during the monsoon shake the trees violently, with th result that the roots are torn and considerable damage is don to the trees in this way. In Ceylon (12) the sapota is said t prefer a rich sandy loam, although it has been known there t do well even in poor soils if well manured. In South India

ıpotas have been grown successfully on gravely poor ıterite soils of the hill slopes of the Western Ghats. The Indo ;angetic alluvial soil of Bihar and the United Provinces are very :ell suited for its culture, provided the climate is not too cold uring the winter.

The climate of the tract between Bombay and Surat is equiable. The maximum and minimum temperatures approximate

Climate

92°F and 52°F respectively. The average rainfall is about sixty inches per annum, and distributed over three months from June to the end of Septemer, the heaviest rainfall being during the months of July and ugust. The tract is coastal and winds are very strong at the reak of the monsoon. The humidity of the atmosphere is geneally high. The sapota plantations here are exposed to the direct alt breeze from the sea and have to be protected by suitable vind-breaks. *Bhend* (*Thespesia populnea*) trees are planted ll round the sapota plantations for this purpose. Cocoanut rees are also raised in thick rows, to provide a wind-break as vell as for augmenting the income to the owner If this windreak is not provided the foilage of *chika* trees on the seaside is corched severely, and this causes considerable damage to the rees. This phenomenon is noticeable in many orchards at Gholwad (3). Parsons (12) thinks that, in Ceylon the sapota "is best suited to the low country wet zone, but will thrive n less moist regions also." *Chiku* is very susceptible to cold njury even when it has grown to be a large tree, and very rarely hrives where frosts are frequently experienced. This is the eason why it is scarce in the Punjab and the lower foot hills of he Himalayas. In the southern parts of the United Provinces nd Bihar, however, sapotas are in greater evidence and thrive specially and well in sheltered localities.

All over the world, sapota is propagated by seed, gooty nd enarching. Parsons (12) states that budding is also possible.

Propagation

If seeds are used, they are selected from outstanding trees of merit, and sown in pans or repared beds of light sandy soil in Ceylon. Seedlings are translanted usually when they are about two and half months of age, nd are finally planted out twelve to fifteen months after sowing. n South Florida, the propagation is mainly by seed, although it s said that shield budding, grafting and layering are feasible.

May is believed to be the most satisfactory month for budding in that country. Seedling trees produce fruits which are markedly variable, and therefore, vegetative methods of propagation are now being advocated. The most common method of propagating *chiku* trees in Western India is by gooty (Marcottage). Of late, grafting is displacing gooty at Dahanu and roundabout, because this method is easier, and the plants so propagated grow quicker (3). When the *rayan* (*Mimusops hexandra*) rootstock is used, the bearing is said to be good too.

Gooty

Chiku gooties are generally prepared at the end of May or the beginning of June, so as to give them the full benefit of the following rainy season.

From October the gooties are hand watered till the following January, when roots are seen to emerge. They are then severed from the parent tree, and planted in earthen pots and kept in shade until required for sale or planting. Nearly half the number of gooties die subsequent to severing in the pots. Gooties of *chiku* plants thus take eight months to be ready, unlike other plants which get ready in a much shorter period. The long time taken and the small success are the factors which raise the cost of gooty plants. An improvement in the method of preparing *chiku* gooties is lately coming into vogue. After the gooties have passed the first rainy season while still attached to the scion, they are left as they are, without any watering, until the *next rains*. In the second season, they throw out more roots in August. This method saves the cost of hand-watering from October to January and also makes the season of severance more favourable. A rainy day is considered very favourable for severing *chiku* gooties from their parent trees. The above practice is prevalent in parts of South Kanara district of the Madras Presidency where the rainfall exceeds 100 inches per annum.

Layering

Layering is found to be an easier operation than gooty in the case of branches growing close to the ground. Such branches require to be pruned to enable proper cultivation of the orchard land. They are, therefore, used for preparing new plants by layering. Layers, however, take a fairly long time to strike root, and, therefore, do not get ready for planting out for several months.

A special method of layering of litchees, but sometimes

hiku also, is prevalent in and around Dehra Dun in the United Provinces. Earthen pots with a V or U shaped notches at two places opposite to each other and on the edges, are tied to the limbs of the trees close to the shoots intended to be propagated. After the usual operations of exposing the bark of selected shoots are carried out, the shoots are bent and passed through these notches and the exposed parts of the shoots are buried under the soil inside these pots. The separation of the layered plant is effected after a very long period.

Some of the varieties of *chiku* are very reluctant to strike roots by the gooty and layering methods. They have, therefore, necessarily to be propagated by grafting, which method is lately becoming popular for most varieties. *Chiku* seedlings take a very long time to be ready as rootstocks, and hence the *rayan* (*Mimusops hexandra*) and *mohoda* (*Bassia latifolia*) stocks are preferred. Opinion, however, widely differs on the comparative vegetative growth and bearing of trees raised on each of these rootstocks. In Ceylon the two trees *Bassia longifolia* and *Sideroxylon dulicificum* the "Miracular fruit" of tropical West Africa, are said to afford suitable stocks for grafting sapotas (12). *Mimusops kauki* is said to be used as rootstock for sapotas in Hyderabad (Deccan). Sapota trees on *khirni*, however, are reported to be not prolific. At Saharanpur, it is said, that sapotas have been successfully enarched and cleft grafted on *Mimusops kauki*.

Rootstocks

Side grafting of sapota on Mimusops hexandra has been done successfully at Kodur too, and a few sapota trees grafted on this and also on *Bassia latifolia* and *Bassia longifolia* are now growing there in an observational row.

Self-sown seedlings of *rayan* and *mohoda* or *mohwa* are obtained from the jungle and planted in pots for rootstock purposes in the Bombay Presidency. When they take root in pots, they are grafted upon. Grafted trees are popularly believed to bear fruits with granular pulp, which is not relished in Bombay. Gooty trees have, on the other hand, no such disadvantages and, therefore, have been preferred by the Bombay public for a long time past.

Grafting

In the neighbourhood of Gholwad, the land is levelled and pits are taken twenty to forty feet apart in the summer. Pits are usually dug three feet each way. They are filled with

brushwood or rice husk and burnt. They are left expos for weathering until the approach of monsoon, when they a filled with a mixture of about eighty poun

Planting

of sheep dung or farmyard manure, ar the original soil. About thirty pounds of whole or brok bones are often thrown at the bottom of each pit before fillin Planting is done either in the beginning of May, in whi case the plants establish before the heavy showers fall, or aft the rains in November or December. On planting, the your plants are protected from strong winds by supports of stic and from the hot sun by cocoanut leaves, until they strik roots and begin to grow. Hand watering is the practice followe immediately after planting. On the banks of the Ambik river in the Navsari district (Baroda State), the alluvial depo sit on the river banks is particularly preferred to other soils fo planting *chiku*. Planting is not done during the rains, but it believed that if it is done in the month of May, roots of the nev plants establish themselves in the ground, and do not rot when th early rains pour heavily. The spacing given varied in the pas from twenty to thirty feet, but lately there is a tendency toward wider spacing. Gooty plants are used normally for planting which is done in small pits of about a foot cube, with or with out manure. The land is more or less level and loose, and nc preparatory tillage is deemed necessary. Thirty feet spacing i usually allotted in sapota plantations in North and South India In the fertile soils on the banks of the Ganges, no manures are added to the pits before or at the time of planting. In very poor soils, it is considered best in South India to add manure to the pits six months or a year ahead of actual planting. Planting is usually done in February-March, or August-Septembe in North India, while in South India July to January is mos favoured for this purpose.

From October, irrigation starts once in eight days in Western India. The water in the wells is generally insufficient for about two months during the hot weather. It is also brackish in many cases. Watering is, therefore, done once in ten days during this period of scarcity, with the result that a large num-

Irrigation

ber of flowers which open in this season drop and cause a loss, approaching forty per cent o the seasonal (Aug.-Sept.) yield. If irrigation water is available in

ufficient quantities, and if the trees are watered once in four to ix days in the hot weather, it is said that there is no loss of yield in ugust and September. *Chiku* trees generally seem to like fairly ieavy irrigation, and are not seen to suffer much in low lying reas, although stagnant water is not congenial to their best iealth. At Dhamdhacha and Devdha of the Navsari district, *hiku* trees are irrigated in a ring basin. A mound of earth of hree feet radius and eighteen inches high is raised around the runk of trees, with a view to protect them from violent winds vhich are so common especially during the early rains. This nound naturally necessitates the formation of irrigation rings, vhich later on merge into the broad bed system. Of course, he mound continues. Irrigation water never touches the trunk of trees, except perhaps in the very early stages, when the trees iave not grown up sufficiently to require the mound. When the nound of earth has been there for some years, roots of trees freely emerge out of it on the surface and the sides. The exposure of he tip of these roots does not seem to harm the trees much. In this tract the *chiku* trees are not irrigated at all for about two months when they have no fruit on them. This period of rest is utilised for carrying out cultural operations in the plantation. In Bihar and the United Provinces water is rarely applied to sapota trees after they attain the bearing age, except occasionally during March to June, on poor soils. In the west coast of South India watering is never done to large trees, but in the east coast and central districts watering is given only to young plantations and to older trees during the hot period from February to June. On very poor and porous soils, watering is, however, done regularly according to the amount of moisture present in the soil and the amount of precipitation received. *Chiku* trees are hardy by nature and stand a good amount of water-logging at their roots. The subsoil water level in the Gholwad tract is within a foot from the surface during the rains and is generally high throughout the year. The water in many wells at Gholwad is brackish, but *chiku* trees do not at all seem to be affected by its continuous application. In some cases the surface soil develops incrustations of salt, and the health of trees is not damaged to any appreciable extent. Inter-crops of chilli (*Capsicum* sp), *Bhendi* (*Hibiscus esculentus*) and the like do suffer from such brackish water. The growers of Devdha, Dhamdhacha and Bata

villages of the Navsari district consider it beneficial to irrigate *chiku* orchards with brackish water of some of their wells. The actual analysis of this water is not known, but it is believed that the water contains a large amount of common salt. Such brackish water is considered harmful to citrus trees in the same villages.

Manuring

During the monsoon, green manuring with sunn hemp (*Crotolaria juncea*) is often practised. The usual dose of manure consists of one of the following mixtures given twice a year.

(1) Four to five baskets of sheep manure and twenty pounds of fish.

(2) Four to five baskets sheep manure and ten to fifteen pounds of bone meal.

(3) Four to five baskets of sheep manure and ten to fifteen pounds of oil cake.

Farmyard manure is substituted for sheep manure, when the latter is not available. Sometimes poudrette is given instead with great benefit. At Devdha, a *chiku* tree of ten years of age receives twenty to forty baskets of farmyard manure or sheep dung and twenty to forty pounds of castor cake. This manure is given in addition to the heavy applications made for the inter-crops. Some growers also apply upto ten pounds of common salt to each tree, although the necessity or usefulness of this is not known. It is believed in some places that common salt or water from brackish wells stimulates bearing and improves the quality of fruits. There is in this area also another practice of burying banana pseudo-stems in long trenches opened in between rows of *chiku* trees. Banana is a popular inter-crop in these plantations, and after the bunch is harvested, the best use of the pseudo-stem the growers make is to cut it and allow it to rot in the water channels, which are specially deepened for the purpose, and later covered with a thin layer of earth. Some growers even open special shallow trenches for burying banana pseudo-stems, and incorporate them thoroughly into the soil. Experiments carried out at the Poona College of Agriculture have shown that the banana stem has considerable nitrogen value as manure when properly rotten. Slaughter house refuse is also added in addition to farmyard manure or other bulky manures. Well rotten cattle manure applied as light

ressings twice a year towards the end of each monsoon is reorted to be very beneficial in Ceylon.

After-care

The orchard soil is dug in September with the "Irani" foot pade, which implement is confined to Gholwad tract of the Bombay Presidency, having been introduced there from Persia by the immigrant Irani Persian) cultivators. The spade penetrates the ground to a lepth of about nine inches and turns the soil over. Basins and water channels are then made and irrigation starts from October. While making the basins, the mound of earth mentioned above is left near the trunk of the tree to prevent the trunk from coming into direct contact with irrigation water.

Inter-crops

Besides the banana (*Basrai* variety), Paul Neran variety of rose is grown as an inter-crop in a number of *chiku* plantations of Dahanu and Gholwad. The flowers of this variety are large, brilliant in colour and lasting. They thus command a good price in the Bombay market. Guavas are also sometimes planted between rows of *chiku* trees. Papayas, annual vegetables such as chillies (*Capsicum* sp), tomatoes, brinjals (*Solanum melongena*), cabbage, etc., are also grown in some orchards. Inter-crops are grown and yield income for five or six years in the early stages of plantations, and have then to be discontinued or removed in order to leave the whole orchard to *chiku* alone. Banana as has already been mentioned is a very common inter-crop in many *chiku* plantations, all the popular varieties such as the *Soneri* and *Basrai* being included. Banana plants remain in the stool for several years after planting, and yield a substantial income as well as a useful bulky manure. Besides, inter-crops of *suran* (*Amorphophallus campanulatus*), turmeric (*Curcuma longa*), ginger (*Zingiber officinale*), *tur* (*Cajanus indicus*), etc., are also grown in *chiku* plantations by rotation. Most of these crops require heavy manuring and irrigation which add to the fertility of the soil of the orchard.

Bearing

Chiku trees commence to bear fruits from the third year after planting. Some gooty plants bear fruits on them even while planting. These fruits are few, and no serious attempt is made to remove them. From the fourth or fifth year a fair income is realised, and it continues to increase from year to year until the trees are about thirty years old. In average plantations the bearing decreases after this

stage of trees. Seedling trees of *chiku* are said to take seven to eight years to come to the bearing stage. Flowers appear on *chiku* trees almost throughout the year, though blossom is more profuse in the rainy season, and less so in April and May. Fruits ripen in about six months from the time of flowering. Hence, fruits are harvested in large numbers between December and March. They gradually decrease until they become scarce in September and October. Fruits harvested in summer are generally well developed and large in size. In Ceylon the sapotas bear two crops a year, one during August and September, and the other during February and March. The former crop is the heavier of the two. Some varieties, however, fruit nearly all the year round. In the Hyderabad (Deccan) State, both the round and oval varieties of sapotas are reported to bear two crops, a year, the *Mrig bahar* and *Ambe bahar* (11). In South Florida, the season of blossoming is said to be irregular, resulting in a succession of ripening fruit throughout most part of the year. In South India sapotas become available in the market from January to May, while a few fruits are also available from August to October.

Harvesting

In the Gholwad tract, large teak-wood posts are planted all round the tree, and cross pieces are tied to them, both with a view to support the tree and its heavily bearing branches against violent winds, as well as to enable easy hand-picking of fruits from the widely spreading branches. Pickers climb up the structures for harvesting fruits. Picking is thus systematized and causes no injury to the fruit. But it requires a good deal of investment to erect these structures. As the Gholwad tract is close to forest area, the necessary teakwood is available there cheaply as compared with other *chiku* growing regions, where this system is not prevalent.

Chiku fruits develop light yellow bloom on full maturity and shed most of the brown scaly material formed on the surface of immature fruits. When they are scratched, no latex will ooze out, and it is a matter of considerable experience to judge the maturity of the fruits before picking. Parsons (12) recommends that sapota fruits should be picked when practically ripe and kept in a dry room or shade for several days until they are soft to the touch. Fruits are col-

cted in Gholwad in bamboo baskets, which are carried by ckers on their backs. Fruits are picked with small stalks n them. Care is also taken to see that no damage is done to em while picking. At Devdha and roundabout, *chiku* fruits are cked three or four days after the irrigation turn, when the il below is soft, but not wet, either by hand or with a stick, nd are allowed to drop on the soft soil. It is the popular belief nat the fruits do not receive any damage by dropping on the ft soil, sometimes even from a height of ten feet or more.

An average tree of ten years of age is known to yield 2,000 uits per annum. The immature fruit contains tannin and latex. In taste most of the varieties are very astringent in the unripe stage. A milky latex is also found n the bark of the tree and this is known as chickle. In Mexico nd Central America chickle is secured by tapping the trunks nd is used largely as a basis for the manufacture of chewing gum. n other countries as in India, *chiku* is grown essentially for table urposes.

ield

On picking, the fruits are spread out on mats under hade for a few hours in order to allow the latex, if any, to dry up. Or else the appearance of fruits is spoiled by it. Grading of fruits then follows, nless the quantity harvested is less than a basketful, in which ase no grading is done. Two or three grades are commonly ecognised according to the size—large, medium and small. These sizes are not standardised and they seem to vary vith each grower. Fruits which are generally small are not raded at all.

rading

Conical bamboo baskets are used in two sizes for packing *chiku* ruits. Dry leaves of banana form the packing material. These leaves are carefully preserved in summer for use in monsoon. The baskets are lined with hese leaves, and on them the graded fruits are placed in layers. Even within the same lot, medium fruits are placed at the bottom, smaller ones in the middle and large ones at the top in each basket. The ends of banana leaves are then folded inside, and the basket is closed by stitching the lid on. A label is then attached to it, and the package is ready for its journey to the market. The two baskets are tied together with their closed lids face to face, and touching each other, the whole giving

acking

the appearance of a single oval drum-shaped container. B this method, the growers save *hamali*, and other haula charges which are levied not on the weight but on the numb of packages. Moreover, this system makes the packages saf against pilferage or rough handling during transit, as the frui inside get an all-round bamboo cover.

Marketing

Bombay is the chief market for the Gholwad fruits, which a not sold to local contractors. The growers send them to the agents in Bombay direct. The agents se the baskets on consignment basis. Lon smooth and yellowish green fruits command a higher pri in the market than brown ones do. Sales are conduct in the market under cover as in the case of most other fruit The grower receives a "*patti*" or account memo the next da giving details of the sale price, agency charges and other mark expenses. Material differences between the prices quoted neighbouring growers on the same day for the same quality fruits are not infrequent.

The Bombay commission agents also send fruits to Poona Baroda, Ahmedabad and other Indian cities. The growe of Gholwad are so much in the hands of the Bomba agents, that it pays the agents to receive the consignments fro the growers and transfer them to Baroda and other market the same way back. But it does not pay the grower to sen his consignments direct to those places. An improvement in th system of marketing is dawning and the growers, realising thei real loss in the original system are attempting to catch th various markets themselves. The *chiku* fruits of Gandevi area ar considered to be inferior in size and quality to those produced a Gholwad. The fruits are, therefore, unable to stand competitio with the Gholwad produce in the Bombay market. Perhap the nearness of Gholwad and places in its vicinity to Bomba also reduces the railway freight on the produce as compare with the fruits from Gandevi area and thus offers an advantag to the former over the latter. Fruits of Gandevi area are, there fore, mostly consigned northwards to Karachi and other town in Sind and Kathiawar, where the Gholwad fruits have th disadvantage of distance.

The results of the storage trials of *chiku* fruits from the Barod State showed that the fruit kept at temperatures 32°F to 45°F di

ɔt ripen satisfactorily, though it remained in a hard and sound ·ndition for forty days. The fruit of the B stage of maturity ripened normally at 52°F, and remained in good condition for five weeks. The fruits of ɔth the A and B stages of maturity ripened well at 56°F and mained in good condition for about a month (6). It has been .own that green *chiku* fruits can be kept for one month at a mperature between 40° and 50°F, after which they ripen nor- ally on removal from the cold storage. Smith (14) from .maica states that unripe sapotas were stored successfully for .xteen days at 45°F. Wardlaw (15), however, finds that, at .rinidad the range between 45°F and 50°F was less favourable. onzalez (8) in Philippines has recorded that mature fruits eld at 32°F and then removed to about 85° ripened normally. .ipe fruits which usually keep for three to four days can on the :her hand be stored successfully for two weeks at 32°F. Campo ł) found that for both green and mature fruits, the best storage :mperature was 59°F, the fruits having been successfully stored t this temperature for eighteen and sixteen days respectively. .t 32°F, ripe fruits were held for twelve days at which tempera- .ıre green fruits could not be stored for more than five days.

old storage trials

No attempt has yet been made to preserve *chiku* fruits either ı cans or as other preserve in Western India. This question is attracting attention in recent years, because fresh fruit does not fetch a remunera- .ve price to the growers. The fruit is a poor keeper too, and ence it cannot be sent to distant markets. It would, therefore, e essential to evolve methods of preserving it in various forms, nd to transport it in refrigerated vans to distant markets in order ı extend its cultivation. In the Vizagapatam district of the 1adras Presidency, a small canning firm has canned sapotas in ıgar syrup as a trial measure. The product when sampled was ɔund to be excessively sweet. Further trials with syrups of arying strength are now being carried out. In some parts of .merica, sherbats of sapotas are said to have been tried. Jams, ıerbats and canned fruits in dilute syrup are some of the products f *chiku*, that are believed to be possible and merit further etailed investigations.

'reservation

Three analyses by Chace, Tolman and Munson (9) of he flesh of Cuban Sapotas, designated mamey colorado,

Chemical composition

and one analysis by Pratt and Del Rosar (7) of the flesh of Philippine sapot designated Chico mamey, are shown in th following table:

	Flesh in fruit	Solids total	Solids insol	Protein	Acids as citric	Sugar re-ducing	Sucrose	Ash total	A All
	%	%	%	%	%	%	%	%	cc
Cuban	75	30·99	6·55	1·09	0·13	11·97	9·03	0·84	6(
Philippine	70	31·2	9·7	1·23	0·18	8·52	8·00	1·26	119

*cc. N/10 acid per 100 grammes pulp. Quoted by Winton and Winton (16

Adriano (1) reports the following results on the flesh con stituting 81% of the fruit-solids 15·45, protein 0·60, fat 0·14 fibre 0·81, nitrogen free extract 13·47 and ash 0·43 per cent.

Chace (9) found 0·80 and 0·89% of ash in the flesh of samples of Cuban sapota and the amounts of mineral con stituents in the ash were:

	K_2O	CaO	MgO	P_2O_5	SO_3	Cl.
	%	%	%	%	%	%
I	50·57	1·38	1·36	4·90	3·54	17·34
II	48·20	1·73	3·35	9·66	3·80	16·00

*cc. N/10 acid per 100 grammes pulp. Quoted by Winton and Winton (16

The chiku tree is comparatively free from diseases and pest caused by fungoid organisms and insects. Recently, however,

Diseases and pests: fruit borer.

fruit borer (3) which is not yet studied is see to attack the fruits generally at the point c contact of two or more fruits, when they ar borne in bunches. Singly borne fruits are also attacked by i

ɔ remedy is yet available to combat it. The stemborer

emborer

(*Arbela tetraonis*), is a minor pest. The borer should be extracted out or the gallery treated th carbon bisulphide or some volatile material and the opening ugged and plastered.

Mealy bugs (*Phenacoccus icervoides* Gr.) attack tender oots of *chiku* trees in large numbers, and deface the fruits.

ealy bugs

Spraying with kerosene oil emulsion or fish oil soap is effective against this pest. In South dia this insect becomes occasionally a serious pest and it has en recommended that pruning of badly infested shoots and raying with a contact poison are the successful control easures.

Scale insects of greenish yellow colour and more or less of dentary nature are sometimes found on the tender leaves and

ale insects and oty mould

shoots of sapota trees. Gradually these insects devitalise the plants and cause the development of an unsightly coating of sooty ould as an after effect. Early spraying with a strong contact ɔison controls the pest. When the sooty mould has developed, raying with half per cent Bordeaux mixture to which starch iste has also been added, serves to liberate the mould flakes.

Galls are often formed on the stems of *chiku* trees. Several lls may be seen on a single tree. The gall seems to be

alls

a hereditary malformation. It retards the growth of the branches above, and affects their aring capacity. Tender root tips emerge from the base of the ll as in the case of a gooty plant. Gooties obtained from lled trees, are known to form galls on them. Being a here-ary physiological trouble, it seems to be incurable. Selection scions from healthy trees appears to be the only possible eventive measure at present against galls.

Flower shedding seems to be one of the most serious

ɔwer shedding

physiological troubles with this fruit tree. Exactly what causes this phenomenon is not ssible to say at present as no study of this question has as t been made.

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CHAPTER IX

FIG (*Ficus Carica* L.)

Introduction

The district of Poona is the chief centre of fig culti tion in the Bombay Presidency. Even there, plantations restricted to a very few places as for ample, the Purandhar and Saswad taluk The total area in the Province of Bombay is 1,230 acres (194 Leading fig growing countries are Italy, Spain, Turkey, Uni States of America, Greece, Algeria and Portugal, total acreage the world being 1,625,000.

A few acres of fig are also found in the district of Ahm nagar and Satara, which adjoin the Poona district. Lately cultivation of this crop is being attempted on a limited scale other parts of the Presidency such as Gujerat. In the distr of Poona, the fig crop was bringing a fair return to the grov until the recent appearance of the serious disease of rust. T havoc played by this disease is so great that growers are actua destroying their affected plantations, and replacing them those of *Santra* and *Mosambi* oranges. Fig, however, is a v delicious fruit and it promises to spread out to new regions a as the control of rust becomes more effective by the efforts of Bombay Agricultural Department, its cultivation is bound prosper.

Origin and distribution

The orginal home of the fig tree is the Mediterrane coast. Fig cultivation is found in several countries of the te perate zone, such as Spain, South of France, Italy, Greece, A Minor, Afghanistan, Florida, Texas and California. In Egy fig cultivation is limited. Generally eve where effort is being made to increase a improve fig cultivation. In India, besi Poona, fig is cultivated on a limited scale round Sahranpur the United Provinces, Bangalore and Penukonda in South Ind In Northern India, fig cultivation is hindered by serious atta of the stemborer. Lately the Mysore Government is tak active interest in the extension of fig plantations as a par their rural development move.

In Greece, an organisation known as the Office for the pro-
tion of Greek figs is mainly responsible for its improvement.
a Minor exports to other countries about 75,000 tons of dried
; annually, and the authorities zealously protect the secrets
its cultivation by prohibiting its study by foreigners. In the
stern districts of Morocco, there are over 1,600,000 fig trees
ich are subjected to taxation. California in the United States
America produces as much as about 5,40,000 boxes fresh and
000 tons dried figs annually, the total being valued at 920,000
llars (1928). In Egypt, the fig industry is not quite self-suffi-
nt. This country imports for internal consumption dried
s worth about £50,000 annually in addition to its indigenous
oduction of fresh figs.

rieties and ssification

The edible fig belongs to the genus *Ficus* of the Natural
der Moraceae. Generally two distinct types of figs are recognised in commerce, the edible fig and the caprifig. The latter is a male type. Its fruit harbours the fig wasp called the *Blasto-
ıga*, which is the chief agent to transfer pollen from caprifigs
edible ones. Hence the economic importance of the
prifig, although its own fruits are of no direct utility.
lible figs are mainly grouped into two divisions, the Smyrna
s and the Adriatic figs. Smyrna types such as the *Lob
ir*, *Kassaba* and *Eisen* require caprification or pollina-
n by the *Blastophaga* insect, without which they cannot
velop mature fruits. The successful cultivation of these
rieties, therefore, depends upon the rearing of the caprifig
es. On pollination, fruits of these varieties generally develop
ds. They also contain a high percentage of sugar, on
count of which the fruits lend themselves easily to drying
d keep well for a long time. Unlike the Smyrna figs, the
riatic figs develop without caprification. The type grown
the Poona district and what is known as the Coimbatore in
roda and parts of Gujerat, belongs to this group. A large
mber of varieties grown in the South of France, Italy and
ain are Adriatic types. Fruits of these varieties are good for
table. Some of them such as of the *Kadota* can be dried
o. Only three classes of figs are known on the basis of
wers borne within the receptacle, namely, Common figs,
nyrna figs and Caprifigs. Most of the innumerable varieties

of figs grown in Europe and America are grouped und the first class. The development of fruits in this class somewhat analogous to that of navel orange and the banan the female flowers remaining unpollinated, and the frui therefore, being seedless. The apparent seeds are hollow she without the inner kernel and germ. The Mission ar Brown Turkey are two important varieties of this grou Smyrna figs have long slender styles as common figs hav but they require the stimulus of pollination to enable t fruits to set. Without the stimulus the flowers soon tu yellow and drop. Common figs can produce fertile see when caprified, but caprification is not necessary in their ca for setting fruits. Caprifigs are mostly inedible on accou of presence of insects and a mass of dry male flowers withi the eyes. They set fruits only when stimulated by the *Bla tophaga grossorum* by laying eggs and developing larvae withi their gall flowers. In classifying the various varieties of fig Bobone (1) attaches importance to fruit characters like shap and size of fruits, colour of skin, roughness of surface, colour cor sistency and flavour of flesh, length of peduncle, etc. O the basis of these characters, he described 52 varieties whic according to him, are grown in Portugal alone. Grasovsk (20) described about 40 varieties grown in Palestine. In Ital Ravasini (27) describes 50 varieties as grown in that countr In India, a type of Adriatic fig of high quality and perhaps orig nally introduced at Coimbatore, is becoming popular in th Baroda State and other parts of Western India. It is locall known as the Coimbatore fig and is considerably superior to th Poona type. Several fig varieties, namely, Poona, Bezwada Ganjam, Bangalore, Myceram, etc., have been tried at th Fruit Research Station, Hassarghatta, Bangalore. Bezwad variety seems to be very productive. Bezwada variety on *Fic Palmata* stock has given good yield.

Soil

In the Saswad taluka of the Poona district, the soil in whic fig trees are cultivated successfully is medium black with a larg admixture of lime nodules in it. Plantations are generally locate on the sides of hills and near *nallas* (streamlets which permit a thorough drainage of the soi Plantations which are open to high winds do not seem t suffer on that account. Especially in the summer months, th

lants perhaps benefit by exposure to winds. Near Surat at achin fig trees are found to thrive well. The soil of this area is milar to that of Saswad, but the rainfall is nearly double. he Sachin soil is, however, much deeper than that of Saswad, eing ten to twelve feet deep as against two to four feet at Saswad. n the Baroda Government Farm, where the soil is light loamy nd very deep, fig trees of both the Poona and Coimbatore arieties are found to thrive. The Poona type bears less nd smaller fruits, while the Coimbatore produces large fruits of igh quality. In general, fig trees seem to be more sensitive to limatic conditions than to soil. They are seen growing well ractically on all kinds of soil, provided there is an adequate upply of water during the fruiting seasons. They do best in lluvial clay loams, as such soils are well drained and conserve nough moisture. Sandy soils are not quite good for fig trees, nless they are supplied with enough organic matter and lime. he presence of these ingredients in sufficient quantities is essenial to induce fruiting. In Asia Minor a soil which is conidered best suited for the cultivation of fig trees has the followng composition:

	Sample 1.	Sample 2.
Stones on fine matter	26·90	38·99
Moisture	0·22	0·28
Organic matter	2·56	2·80
Nitrogen	0·04	0·06
Calcium carbonate	0·60	0·60
Phosphoric acid	0·28	0·28

n Greece, it is stated that the fig tree is not exacting in s soil requirements, but shows a preference to a soil which is ool, deep and not too light. Borg (3), in the Maltese Island tates that the fig can grow on all soils which are free from tagnant humidity. It has got a powerful root system and hence elights in deep soils especially where there is a deep broken or orous subsoil. Sandy soils with an adequate amount of lime and rganic matter produce fruits which are high in sugar contents nd are superior in colour after drying. A red loam with a my substratum and about three feet deep is considered the best or figs in the fig growing tracts of South India.

The fig is chiefly a fruit of the sub-tropical and temperate egions, although several writers have classed it as exclusively a

sub-tropical fruit. The climate of the Deccan, and in fact any pa of Bombay Presidency, does not appear to be ideal for its healt

Climate

and growth. As in the case of grapes, fi in this tract bear a good crop during winte the crop ripening in the months of March and April. The fairl cool nights of the winter months help the fruits to harden up The quality of ripe fig is, however, good and marketabl though it cannot equal that of the Smyrna figs. Effort is, there fore, being made to preserve and extend fig plantations in thi tract as far as possible. Though low temperature is not harmfu to fig trees, a hot and moist climate is. Even humidity may no matter if the temperature is sufficiently low. Smyrna trees ar more sensitive to climatic conditions than Adriatic ones. Th former are confined to regions where winters are sufficientl mild in order to enable the *Blastophaga* to live through withou injury. Warm climate is necessary for growing figs meant fo drying purposes. There should be no rain or heavy dew-fall t enable the fruit to become dry and hard. Cold nights durin winter help fruit to become dry and hard, while they retar the formation of sugar in them. Severe cold makes the bark o trees crack. In Africa young branches of trees are besmeare with cowdung to protect fig trees against frost. Rainfal affects the fig crop considerably, especially under the condi- tions of the Bombay Presidency. Where rainfall is scanty, the crop is more successful than where it is heavy. The Saswa area which is a plateau has a rainfall of 14 to 20 inches per annum. The climate is dry and warm during the fruiting season. Still, occasional showers during the months o April and May damage ripening fruits considerably. Rain- beaten fruits are insipid in taste. Rust is encouraged by cold winds following heavy showers to the detriment of the crop The fig trees go to rest during the rainy season in th Deccan and these trees thus become leafless, while most othe trees put forth new growth. It may be that the leaves drop due to rust caused by rain. While the heaviest rains are res- tricted to June to October, the months of December to March are practically dry and helpful for the development of fruits. Unusually warm weather when the immature figs are develope causes the fruits to drop. Some varieties like Kadota fig ar stated to be particularly affected by high temperature in Jun

.nd July in California. Proper attention to soil moisture is aid to minimise this loss. Frost also affects young fruits, growth .nd crop disastrously, and weakens dormant fruit buds. An :quable temperature during growing and fruit developing eriods is, therefore, essential for successful fig culture. In Asia Minor it rains practically throughout the year, the average ainfall being about two inches per month, except during the nonths of July and August which are dry. This dry period s congenial for ripening and drying of fruits.

Propagation of fig trees by the use of cuttings is the most com- .non method employed in all fig growing countries of the world.

?ropagation

Cuttings are taken from terminal branches, which are about one year old. Such cuttings ave short internodes, and they yield a high percentage of uccess, and produce vigorously growing plants. Cuttings are lanted in nursery beds at the commencement of the rains. They ecome ready for planting out into the field in the follow- ng year. It is easy to propagate the fig tree by layering and gooty also. As the tree is vigorous and productive on its own :oots, it is not necessary to resort to the use of a rootstock. After planting cuttings, care should be taken to remove air- ockets by working the soil in between the cuttings. Grafting of fig trees can also be practised with some success. But this nethod is not much employed. By grafting it is possible to convert established inferior trees into better ones. In South Australia, fig trees are grafted by side grafting, but the enefits of this operation are not clear, excepting top-working unproductive trees with improved types. The Poona fig can be udded on *Umber* (*Ficus glomerata*) and it was also found pos- ible to side-graft cultivated fig on *Ficus glomerata* at Kodur, ut this method is not worked out sufficiently to prove its advan- ages, which might emanate from the use of hardier, root- tock plants. Cleft grafting can also be practised if care is taken o exclude air and may be done during the early spring (7). Also cuttings are taken from one-year-old wood which is tocky, smooth and short-noded. The length of cuttings lepends upon the nature of the soil, being 30 to 40 cms. in andy soils, and much less in heavier soils. Seedling plants are also raised using seeds which sink in water, but as they vary in he quality of fruits they produce, they are not commonly

planted. In Greece fig trees are propagated by layering, mature wood of about two-year-old being employed for this purpose. When cuttings are used they are planted upright and covered with soil, so as to bury the terminal bud to a depth of two to three centimeters. Borg (3) states that budded or grafted trees of fig are more vigorous and produce finer fruit than trees raised by layering or cuttings. Although cuttings can be planted out in the field soon after rooting, they are allowed to remain in the nursery for about two years to become strong. Grafting is generally done in February and March, and budding in March to September.

When budding, the ring method may be adopted on small rootstocks (7), and the patch or shield methods for larger ones. One to three-year-old branches can be top-worked by shield budding at the time when their bark slips easily. Buds should be cut larger for older branches. Usually, cleft and rind grafting are adopted for top-working fig branches of three to four inches in diameter. The scion used is two-year-old with three or four buds. Scions and stubs are protected by perforated paper collars, and the limbs are white-washed to prevent sun-burn.

In the Madras Presidency the demand for fig plants raised by layering and gooty is greater at present than for rooted cuttings. Cuttings are believed by some of the growers to be more liable to the attack of white ants than layers. Suckers which appear at the base of trees make good planting material, especially if roots are developed on them.

When the site for raising a fig plantation is selected, the land is cleared of all brush wood and wild growth, ploughed and harrowed several times, levelled and got ready for taking pits. Spotting of the pits depends upon the spacing adopted. Spacing of fig trees depends upon several factors such as the texture of the soil, growth habit of the variety and the form of cultivation desired to be adopted.

Spacing and planting

Spacing is, therefore, found to range from 8 to 10 feet each way in Palestine, 40 ft. in Africa and 60 ft. in Smyrna. The usual spacing allowed to fig trees in the Bombay Presidency is fifteen feet each way. The plants remain as bushes and do not grow tall. If the spacing is increased to 18 to 20 ft. it faciliates inter-culture in the plantation. At present, with 15 ft. distance, all cultural

perations are carried out by manual labour. Pits are dug t the required distances, their size being one and half to two eet cube. It seems desirable that the preparatory tillage is ompleted and pits are taken during the summer months efore planting, so that the pits can be left exposed to the un and wind for weathering for sometime. Just before the dvent of the rains, pits are filled with their original soil, mixed vith about eighty pounds of cattle dung manure. While lling the pits, the original soil is reversed as in all cases of fruit lanting in the region by placing the top half at the bottom and he lower half on the top. The soil is well pressed on filling, ayer by layer. When the soil is fertile or where there is danger f white ant attack, manure should not be added to the soil in he pit at the time of planting. When the rains start and the round is thoroughly wet, planting is undertaken. One or two ooted cuttings may be planted in each pit, burying only the root portion in the ground. Soon after planting, the plants are vatered well. If rains do not intervene, watering is repeated every week until the plants are established and begin to grow.

Manuring

In the first year, one basket or about twenty pounds of old vell rotten cattle manure or sheep dung is given to each plant. It is gradually increased to five to eight baskets when the plantation is eight years old, and hen maintained at that dose per annum. Oilcake, ash and bone-neal manures are also being given lately in varying quantities in order to encourage good yields. Manures are given generally it the start of the monsoon, during the first two years of the lantation. But when the tree is treated for the crop (*bahar*), nanure is applied about the end of September, when after he trees have been rested, water is given to them. Night soil s applied to figs by some growers in Bangalore after mixing it vith red earth and sand. Sewage effluents have also been ised with benefit for fig near Bangalore. Tannery refuse is also aid to be popular in some places. Most of the fig growers in outh India believe that a mixed manure made up of sheep lung, cattle manure, red earth and sand is required for successul fig production. Organic manure is usually applied in the dornant season of the trees, while fertilizers are applied late in pring or summer. The best time for applying manures seems to be when new growth starts.

Irrigation

Fig trees in the Deccan require irrigation throughout their li time between October and May. During the rains, they are n watered, as that is the season for them to re Curiously enough, fig trees shed their leav and stop growth in August and September in this region. Abo the end of September or early in October, they are manured a irrigation is resumed for the winter crop. Where for want water or for other reasons irrigation is given once a fortnight so, fruits are seen to develop to a larger size and become sweet than in places where water is given more frequently. After t rest, irrigation is given sparingly and increased gradually about three turns. Fig orchards being of very small sizes some parts of South India, are mostly watered by hand, at inte vals of three or four days. Too much water is said to make t fruits insipid, while its deficiency renders the fruit small an hard.

In countries like Asia Minor (6), where rainfall steady and well distributed throughout the growing perio artificial irrigation is dispensed with altogether. The cultiva tion of fig trees, therefore, becomes less expensive. In Poona the trees require ample water during the hot weather whe fruits ripen. This factor considerably adds to the cost of pro duction of fruits. In California, fig orchards are irrigated onl when the soil is dry. Abundant irrigation to trees is said t lower the quality of fruits produced. It has been observe that fruits collected after a dry period are less sour than thos collected immediately after an irrigation. During the earl years of the fig plantation, inter-crops of vegetables such a beans, peas and *matki* (*Phaseolus aconitifolius*) are grown. N inter-crop of the type of *jowar* (*Andropogon sorghum*), brinja (*Solanum melongena*), chillies (*Capsicum* sp.), tomatoes, etc is grown.

Training and pruning

The fig plants have a tendency to put forth new shoot from all their buds, especially when they are young and vigo rous. This results in a large number of shoot springing from close to the ground and ofte from under the ground and makes the plants bushy. The Sas wad cultivators allow all these shoots to grow under the impres sion that the larger the number of shoots the greater is the yield It is also considered that the trees with a number of shoots risin

can resist strong winds. Further, in cases of stemborer ıck or other troubles the attacked branch may be pruned off, ving part of the tree at least in tact. Observations have wn that the lower shoots can be nipped in the bud and a ıng, single stemmed tree can be raised with several vantages. If the tree has a clear stem upto about three from the ground, operations of cultivation can be carried with bullock power and plantations can be kept clean. th judicious pruning and notching on the single stem, a l balanced tree can result with normal productivity. The nborer trouble is minimised in a clean grove, and any such ıck can be at once detected and treated from the beginning. If trees are headed back to 18″ to 24″ at planting time, leaving y three to four well developed and evenly placed side branches round the plant, proper shape of the tree and strength the framework are ensured. Periodic examination will necessary in the case of such trees in order to prevent growth of unwanted shoots and vigorously growing suckers, ich tend to crowd together in a few parts particularly near pruned regions. Attempt has been made to turn fig trees a trellis fashion but although this method seems to be success- in producing a fine hedge or border row in the plantation, economic or commercial possibilities are doubtful.

In the Deccan, fig trees are grown by the cultivator as shrubs, l not much of pruning is practised. Pruning when done is y light. During the earlier stages only too much crowding is eved, and when the annual growth slackens down later, re heading back induces fresh growth and is followed by t pruning. On the Jagudan farm (Baroda State) excessive etative growth which was sterile was heavily pruned back, ı the result that new fruit bearing shoots were produced. the Baroda Government Farm also pruning has induced fresh t-bearing spurs.

In several countries pruning of fig trees is practised in order ıdmit light and air and to prevent crowding up of branches to improve shape of trees. Sterile twigs found at the base nain branches are cut off annually. The centre of tree is ıned out. In case trees are not evenly balanced, branches on larger side are pruned back to establish a balance. There two systems of pruning. One is the winter pruning and the

other, the summer pruning. The effect of the former practi during the dormant period of the tree, is to stimulate grow when the tree returns to vegetative activity. The latter reduc the absorbing and elaborating plant parts and retards grow considerably. Old fig trees are renovated by shortening t main branches to a stump in winter. For Adriatic fi thinning out and occasional heading back is said to be usef in forming a good amount of new wood. In the case Kadota figs, trees are headed very low and the new branch are thinned and pruned back every year, so as to produce lo headed open-centred tree. Caprifigs are not pruned so dras cally. Heavy winter pruning of unfruitful fig trees is practised California, especially in Kadota and Brown Turkey varieties ar the Magnolia in Texas, to stimulate a heavy vegetative growt bearing later in the season a second crop of figs in abundanc Such heavy winter pruning is not, however, advocatd when t fruit crop of figs is desired, as pruning will result in a loss of t wood bearing dormant fruit buds. Heavy summer pruning practised, but this is said to be undesirable. Sometimes, fig tre are planted and trained for two forms—the shrub and the tre In the shrub form, pruning back of current season's grow is found to increase the yield by about sixty per cent. In th tree form, pruning is done first for training the young tree ar later for improving the yield in old trees. The main object pruning in both the cases is to build up a strong fram work to enable the limbs to carry on the yield of fruits witho damage to the health of the trees.

At Bangalore the fig tree is allowed to grow straight to height of about three feet and then it is topped (34). Th induces it to branch out. The branches ultimately reach height of about seven feet. But topping is not practised Bellary and Penukonda in South India. In fig trees the woun caused by pruning do not heal up quickly and as a result pr mature decay occurs, especially when stumps are left at the ba of the pruned branch. Small or secondary branches should neatly pruned at a point where side branches occur.

Want of sufficient knowledge of the systematic metho of pruning in the Deccan results in the trees assuming scrag forms, though they were properly trained in the younger stag This led to trials in notching on branches to induce dorma

ds to produce new shoots locally and increase the bearing area, the same time maintaining a proper form of the trees. Notching consists of removing a small piece of bark one-sixteenth to one-fourth of an inch broad, d about an inch long, in a slant manner immediately above the rmant bud which requires to be stimulated. The wound caused produces a flow of latex. Care should be taken to event the latex from accumulating and drying upon the surce of the bud, as this would retard the growth of the bud. is notch checks the free flow of sap and stimulates the bud st below it. The bud sprouts soon and grows to a length of out two feet in about three months. It is not desirable to notch ore than two buds a year. The basal buds on a branch do not spond to this practice satisfactorily, while healthy and ell developed buds on the middle part of the branch do. veral authors have advanced their views on the effect of tching upon the health of the plant, but the question ems to remain yet a disputed one. There is no unanimity of inion with regard to the salutary effects of notching. Some orkers have stated that certain inhibitory substances flow own through the bark and check the growth of buds, while lowing a few buds at the top to continue growing. If this is ue, the stimulus of notching on the sprouting of dormant buds ecomes clear.

otching

A few fruits may be produced on fig trees in the first two ars, but they are not allowed to develop, lest the strength and health of the plants be undermined. Fig trees begin to bear a crop from the third year of planting in the Deccan. A good and steady eld is obtained from the fourth year onwards. Fruits ripen om March to the end of May. In South India, fig trees bear ice a year, namely, July to September and again from bruary to May. Fruits produced in the hot weather are more luable as they are good and sweet. In the Saswad area, when uits are intended for transport to distant markets like Madras, ey are picked when yet slightly immature, in order that they ay reach their destination in good condition. The yield figs varies considerably from locality to locality. In the swad area, the average yield from a healthy tree is about rty to fifty pounds per annum, and with 200 to 300 trees per

earing and
arvesting

acre about 10,000 lb. of fruit may be realised from one-acr plantation.

In Egypt, some varieties of fig bear fruits twice a year The first crop is ready for harvest late in June, while the secon is ready in September and October. The fruits are harveste every third day in strong containers which prevent injury t them. The yield obtained from fully grown average trees is fort to fifty pounds each per annum. In Hawaiian islands, ripen ing continues throughout the year. But the main season is Ma to July. In California, the fig trees produce two crops a year The first crop appears on the old wood, the fruit buds pushin out during the spring, and fruits maturing from May to July The second crop is produced on the axils singly on the wood o the present season and ripens from July to November. In som parts, even a third crop is produced, which continues to ripe as late as early January, but this is only a continuation of th second crop. Individual trees bearing little or no first crop, o only first and no second crop, or good crops of excellent qualit in both the seasons are found growing in one and the sam orchards. Wardlaw (36) states that figs should be harves ted when of a light green colour and soft to the touch Gould (19) and Stansel and Wyche (33) recommend tha figs should be picked full grown but just prior to softening. Fruit are picked with about an inch of stalk on them. In humic and warm regions, figs cannot be allowed to ripen on th tree as in warm and arid regions, lest a part of the crop goes t waste.

The nature of flowers of fig trees is found to be different in different varieties. Among the various types known, four distinc

Caprification

kinds of flowers are met with. They are stami nate, pistillate, gall and mule flowers. Stam nate flowers are found in caprifigs. Stamens vary from one to fiv in number with an average of four. Pistillate flowers are foun in the Smyrna figs and generally in all edible figs. The ovary superior with a bent style, which is much longer than the ovar The female flowers are practically the only kind borne withi the receptacle of edible figs. Gall flowers are modified femal flowers and are capable of producing seeds, and are found onl in caprifigs. The ovary of these flowers harbours the eggs an larvae of the *Blastophaga* insect which is the chief agent in tran

erring pollen from the caprifigs. Mule flowers are imperfect owers found in edible figs. They neither develop seeds nor reed the *Blastophaga* insect. These variations in the nature of owers have caused the development of an interesting horti-ultural practice known as caprification in fig culture. This rocess consists of suspending about fifty fruits of the first crop of ne wild caprifigs on the branches of edible types of the Smyrna roups. Adriatic varieties do not need it. The object of caprifica-on is to encourage the production of seeds in the edible figs by rtilising their flowers, with pollens of caprifigs, so that their uits set and mature. The act of pollination is actually per-ormed by an insect called *Blastophaga grossorum*, belonging to the asp family. This insect carries the pollen of caprifigs into the uits of edible types. Only fruits of caprifigs which are called *Profichi*" and which contain the wasp are of any use in the rocess of caprification. Caprifigs are strung into a wreath and ispended on the branches of edible varieties. Fruits are also ispended in small baskets made of one inch wire-nettings. Then fruits attain the size of a marble, they are considered fit receive pollination through *Blastophaga*.

The actual process of pollination by *Blastophaga* is interesting. hortly after the *profichi* (caprifigs) are suspended, the female *lastophaga* hatch out of their galls, and in their effort to ave the fruit, they get covered with the ripe pollen. Once it of the caprifigs, the insects search for other fruits to lay eggs . But when they do not find caprifigs, they enter edible figs r doing so. In this act, they unintentionally pollinate the wers of the edible figs, which are then induced to produce eds and to develop in size and mature. Thus caprification is t an artificial process of pollination accomplished partly by n who suspends the caprifigs and partly by the *Blastophaga* ich carries the pollen to the flowers of edible figs. The summer oods of *Blastophaga* are usually ready for issue from the capri-s about the middle or end of December. As has already been ted, caprification is not necessary for Adriatic figs and is not actised in the Bombay Presidency.

In the Poona district, figs are packed in conical bamboo skets, which are narrow at the top and broad at the base. e baskets cost two annas each and hold nearly fifty pounds fruit. Figs meant for distant markets like Bombay or

Madras, are packed in smaller baskets of about ten pour capacity. While packing, fig leaves are spread inside the basl and fruits are laid carefully in layers on There is better selection of fruits meant Bombay than those meant for Poona. Fruits are sold locally some extent, but in that case they are very well sorted out a graded. Prices are fixed on these grades.

Packing

In California, figs are packed in small boxes, lined w paper, corrugated card boards being used to separate the seve layers in a package. In Smyrna, fruits are harvested wh they are ripe but still hard. Fruits of the choice grade a packed in wooden boxes of 12″ by 16″ size, with a depth corr ponding to the thickness of the large sized fruit. Fruits a packed in single layers in it. The rows of fruits are protect side-ways by white papers from touching and damaging o another. The box is also lined with paper. Fruits of variet which have thicker skin are packed in smaller boxes but double layers. Fresh figs being very delicate, require care handling.

Australian figs were successfully stored at 50°F for twenty-o days (38). Wilcox and Hunn (37) report that ripe figs m safely be held in cold storage at 32°F for about a month.

Transport

Figs are transported in Bombay Presidency to the mark either in bullock carts or in motor buses. The vehicles are used upto the railhead in cases transport to distant markets. Half of the fruits produced the Saswad area is sent to the Bombay market. Of the remai ing half, nearly eighty per cent goes to Poona and the rest other markets like Madras in the South. The prices of figs va from month to month, ruling high when fruits just come to t market in the beginning of the season. The prices are v low during April and May when the fruits glut the mark slightly recovering at the tail-end of the season before the ra starts.

Food value

Figs have a very high food value owing to their prote and carbohydrate contents and high laxative properties. T average composition of the edible portion fresh figs indicates 79 per cent moistu 1·5 per cent protein, and 15·51 per cent total sugars. T analysis of Poona figs shows that they contain 75 per cent

Work carried out in India on the analysis of Figs shows the lowing results:—

Figs	Name
Ficus carica	Botanical Name
89·8	Moisture %
1·3	Protein %
0·2	Fat (Ether Extractives) %
0·6	Mineral Matter %
—	Fibre %
17·1	Carbohydrates %
0·06	Calcium %
0·03	Phosphorus %
1·2	Iron mgs. %
75	Calorific Value per 100 gms.
270	Carotene (I. Unit Vitamin A. per 100 gms.)
—	Vitamin B_1 (1.U per 100 gms.)
2	Vitamin C (mgs. per 100 gms.)
21	Calories per ounce

According to Read, etc. (28), the chemical composition o
Fig in Shanghai is given as below:—

Fig. (Foreign)	Fig. (Chinese)	Name
80	·74	Edible portion %
82·05	83·62	Water %
0·98	0·99	Protein %
14·85	12·58	Carbohydrate %
0·81	0·44	Fat %
0·76	1·92	Crude Fibre %
73	60	Calories per 100 gms.
0·53	0·45	Ash %
0·051	0·049	Calcium %
0·029	0·023	Phosphorus %
0·0013	0·0004	Iron %
0·172	0·180	Potassium

oisture, 15·20 per cent reducing sugars, and 2·1 per cent non-ducing sugars. A sample of dried Poona fig gave the follow-g analysis:—

Ash	3·2	per cent
Ether extract	0·7	,,
Proteins	4·7	,,
Digestible carbohydrates ..	89·3	,,
Woody fibre	2·1	,,

Iawaiian figs are a good source of calcium, poor source of itamin C and a fair source of vitamin A. Brown Turkey fig f Hawaii was found to be a fair source of vitamin A, B and G nd a poor source of C (25). (See pages 395, 396 and 398.)

Winton (39) analyses the edible portion of fig as follows:—

otal solids 14·98%; Solids insoluble 2·37%; Protein 1·40%; Citric Acid 0·21%
Invert sugar and sucrose 10·80% Total ash 0·49%

Diseases and pests: Leaf eating caterpillar

The leaf eating caterpillar, *Ocinara varians* W. is often serious pest of fig trees in the Deccan, and this pest attacks wild varieties of figs also. Hand picking is possible and effective specially on small plants. Spraying with lead arsenate at a strength of one ounce in 3 gallons of water r D.D.T. at 0·2 is quite effective.

Stem borers

Stem borer, *Batocera rufomaculatus* Lin. is another common and erious pest on young fig trees. It also attacks other trees, namely, mango, guava and pomegranate. The insect bores nto the stem and may ultimately kill the plant. The presence of grass outside the hole indicates the attack. By way of control, the insect nay be extracted by means of a thin hooked wire, or may be illed inside by injecting a small quantity of chloroform or arbon bisulphide and closing the hole with mud. Where here is much danger of attack, it is recommended that the runk of the tree be protected with paper painted with coal ar or with $\frac{1}{16}$th inch mesh wire-gauze.

Mites

Mites are also occasionally found to attack the leaves of fig trees causing them to look scorched. Spraying the leaves with lime sulphur wash is the effective control.

Daniel and Munsell (13) reporting on the quantitative data on vitamin content of this fruit reveal as below:

Fresh Fig	Vitamin A	Vitamin B	Vitamin C	Vitamin D	Vitamin G
Brown Turkey ..	80 (Int)	10 (Int)	5	—	33
Frozen					
Mission	100 (Int)	—	0	—	—
Adriatic	—	33	0	—	—
Lob Inger	50 (Int)	—	3-5	—	—
Drid Unsulphured					
Lob Inger	1/5th of fresh	—	—	—	—
Sun dried, Adriatic ..	50 (Int)	50 (Int)	0	0	40
Sun dried, Mission ..	50 (Int)	—	0	—	33-50
Sulphured					
Lob Inger	30% fresh	—	—	—	—
Sun dried, Adriatic ...	—	23 (Int)	0	—	50
Sun dried, Mission ..	78 (Int)	—	—	—	33-50

Int. means International units and others denote Sherman units.

Fig trees are susceptible to the disease called rust, caused the fungus, *Cerotelium fici*, which appears as brown spots the leaves. Heavy rains followed by cold winds during ecember to March, when fruits develop increase the disease.

ust

The affected tree is defoliated and fruits drop prematurely, thus causing heavy loss of the op. This disease has not yet been effectively controlled, al- ough sulphur dusting checks it and minimises the loss of fruits. 5: 50 Bordeaux mixture is an inexpensive and efficient treat- ent, not only holding the trouble in check, but eradicating it in o or three seasons. In America, fig rust has been diagnosed as sty brown spots with pustules containing powdery spores on the ider side of leaves. Affected leaves soon become dry and timately drop. Timely spraying with 5: 5: 50 Bordeaux ixture is found to control the trouble.

Die-back or the dying back of young shoots of fig trees in rly winter, has been noticed in the United States of America.

ie-back

This occurs on weak and straggy trees, which have been injured in the previous winter. This ouble is overcome by suitable manures and resting of trees. A rus disease of fig is recorded from many places in New Zealand. ymptoms of disease resemble those of *Ficus virus*. Symptoms e seen both on leaf and fruit and the virus may be responsible r premature dropping of figs. The virus has been successfully ansmitted by grafting and budding (24).

Fruit drop is a common trouble due to physiological causes. nfavourable climate seems to be the chief factors causing it. uit shedding is attributed to excessive dryness and heat, cold ghts, cold winds and light frost, or moisture deficiency, in

ruit drop

which case fruits which escape shedding develop very poorly and are insipid in taste. edding of figs is also seen to occur in uncaprified Smyrna gs due to lack of pollination.

Sun-burn, which gives rise to disease in fig trees is seen articularly on newly planted young trees, and their tender ranches. As a result of sun-burn, the affected parts crack and the ark peels off. The part so exposed gives access to insect borers.

un-burn

Trees affected by sun-burn and the borers do not grow normally, but remain stunted. Sun- urn can be prevented by taking care to see that the foliage of the

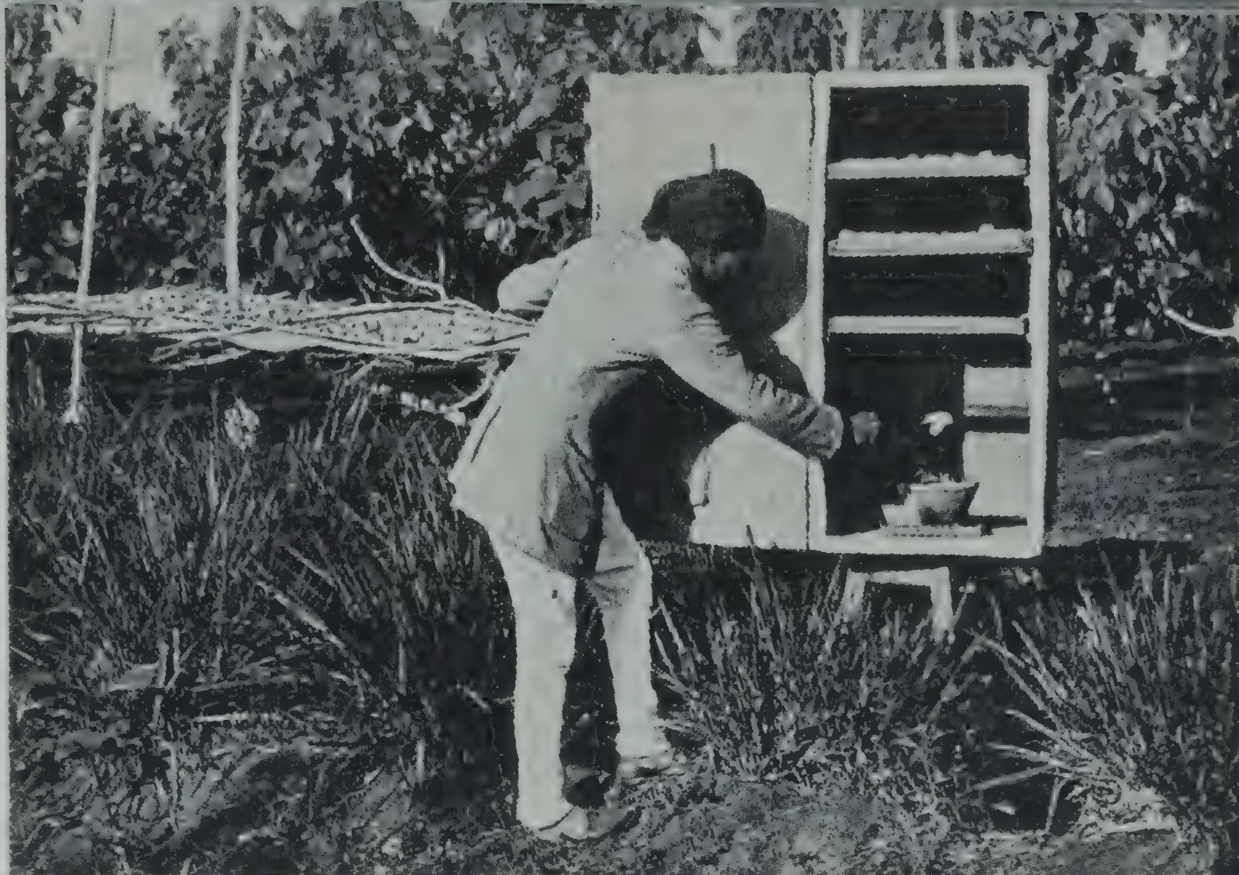
tree is distributed well on all sides so as to shade the branch during summer months. The stems exposed to the sun ma also be covered with paper or straw, or coated with lime avoid the burning effect. Sun-burn is common in the Poo district and damages nearly fifty per cent of fruits.

One of the causes which limit the extension of fig cultivati in the Deccan is the highly perishable nature of the fruit, whi cannot be sent to distant markets without considerable lo At the same time it is interesting to note that about 500,000 l

Sun-drying of figs

of dried figs were annually imported into t Bombay Presidency alone from countries li Turkey, Persian Gulf, Afghanistan, Greece and California befo the second world war. There is thus a market for figs in th country which is not fully supplied by home-grown frui Drying of figs, therefore, has a future as an industry, eve if its scope be limited. Sound but fully ripe fruits aft thorough washing, are cut into halves and exposed to sulph fumes in a sulphur box for an hour and then dried on wood trays either in the sun under dust-proof conditions as far possible or in the home-drier at a temperature of 160°—165° The dried fruit is kept in sweating boxes (*i.e.*, air-tight co tainers), graded and wrapped in pliofilm paper bags just befo marketing.

The Bombay Agricultural Department attempted some yea ago to dry the Poona fig. The process adopted was simpl Ripe figs were picked carefully, and placed in single laye on suitable wire-gauze trays. These trays were then place in an air-tight wooden chamber for about thirty minutes f fumigating with sulphur. Fumigation in this way w found to disinfect and bleach the fruits. The trays with frui were placed one upon the other and flowers of sulphur were i nited below the lowest tray. As the fumes spread in the clos chamber the fruits get treated. In order to avoid over-fum gation the lowest tray was left empty. A suitable fumigati chamber for small scale operations is of the size of 3 ft. by 2 and 2 ft. with cleats nailed to the sides of which, fruit trays c be slided in. The trays are 21 inches by 18 inches and ma of wooden strips with best grade galvanised iron netting havi one-fourth inch mesh. Such a chamber will hold about fif pounds of fruits each time. Over-exposure to sulphur fum



DRYING OF FIGS IN THE SUN.

In the foreground the fruits are being fumigated prior to drying. In the background are seen raised platforms on which fumigated fruits are spread out for drying.

Facing page 400.

ıses figs to develop acidity, which is not desirable. Without ıigation, the final dried product lacks good colour.

After fumigation, fruits are exposed to the sun on wooden :ks. Ordinary bamboo netting, three feet broad and four t high, is found convenient for drying on a small scale. Figs ɔt for drying are turned repeatedly while drying, so as to ow them to dry uniformly on all sides. Drying in the sun is st done in the months of April and May. If rains threaten, : fruits are covered with water-proof canvas. Complete ying takes five to seven days. On drying, the figs become t, pliable and semi-transparent, and are reduced to less than e-third their original weight. Over-dried fruits are leathery d tough. Dried figs contain eighteen to twenty-two per cent ɔisture.

The quality of figs dried in Poona was fair, though it did not me to the standard of the first grade Smyrna figs. In size, lour and softness of the meat, the fruits were very attractive. ı analysis, they compared favourably with foreign products, can be seen from the following figures:—

	Moisture per cent	Reducing sugar.
Sun-dried Poona figs.	19·25	45·95
Persian Fig I	19·45	46·30
Persian Fig II	19·90	45·70
Afghanistan fig	19·04	46·64
Grecian fig	19·14	46·50
Smyrna fig	19·25	57·31

The method of drying figs slightly differs in different ıuntries, largely on account of difference in the quality of ıltivated figs.

Figs are extensively dried in Turkey, Greece, Italy, France, ɔain, Portugal, Egypt and California (15). In Asia Minor, ;s are dried on drying floors. In Italy they are split length-ise, dipped in boiling water for a moment and dried in the .n. In France, they are sweated for two days, after drying in ıe sun for two or three days after which they are again dried ıally. In California figs are fumigated before drying in the ın. Before completely drying, figs are pulled flat as evenly ıd neatly as possible to economise packing space and to ıprove their appearance. Pulling is done by catching the

side of the fruit, so as to flatten it into a circular shape with th stalk and the eye in the centre on either side. Fruits are the graded according to their size and colour. Figs are the dipped in boiling brine (four ounce of salt in a gallon of water for a few seconds. Fruits of the second grade particularl improve by this treatment. Dipping in brine makes the frui soft and improves its taste. After dipping, the fruits ar drained on a wire screen. Dried figs can then be packe for despatch to the market.

Fig jelly

Fully matured but slightly unripe fruit is cut into slice and covered with water and boiled for about half an hour so a to get a complete extract of pectin which is tested with jelmete or with 95% alcohol and the degree of richness of the extract in pectin determined. Th extract is strained through a coarse thick cloth. Calculate quantity of sugar is added to the clear extract and heated t a temperature of 222-223°F so that the jellying point is reached The produce is poured hot into clean sterilized jars and the allowed to cool so that it sets well. After cooling, the surface i covered with a thin layer of paraffin wax to avoid spoilage o the jelly.

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CHAPTER X

BER or BOR (*Zizyphus jujuba* Mill)

Introduction

Of late, the importance of "bor" is gaining ground. nature the jujube or *bor* happens to be a hardy and easily gro fruit, requiring perhaps the minimum labo and attention of the farmer. It can also sta the roughest conditions of soil and climate. *Bor* trees are fou in large numbers on the borders of fields and in uncultivat areas, where they grow without care and attention, except th when they are in fruits they are watched and fruit is harvest and sold. Until lately, regular planting of *bor* trees was not co mon, but realising their economic value increasing attention being paid to them. As a result, the Bombay Department Agriculture had had to deal with many enquiries on this fr crop during the last few years and has rendered practical aid growers, chiefly in the Gujerat and Khandesh districts, in bu ding several thousand wild plants with better commerci varieties. They have also shown the possibility of utilising t *Chani bor* (*Z. rotundifolia*) as a rootstock for raising superi varieties. The selection of a stoneless *bor* may give a great s mulus to *bor* cultivation in all parts of the Presidency.

Origin and distribution

The *bor* is an important indigenous fruit tree of Indi It is known by the words, *bor*, *bari*, *ber*, *bory*, etc., in differe places and in different languages. It known as jujube or Chinese date in Americ It generally occurs growing wild in sever parts of India. A reference is made to its antiquity in t country by Babu Radhakant Deb in a paper found in t records of the Agri-Horticultural Society of Bengal in 18 He stated that in early times the sages of Kashmir, ne the banks of the Alacananda river lived on its fruits. Besic its abundance in the wild state, the large number of known varieties and their extensive prevalence in almost parts of the country not only proves its ancient domesticatic but also establishes its indigenous reputation. *Bors* are wide grown in the eastern districts of the Punjab particular

Hansi and Gurgaon districts. More than a dozen nmercial types of *bor* are found in this area. It is also fairly ensively grown in several districts of the Madras Presidency)0 acres), Bihar (6,000 acres), United Provinces (579 acres) d the Baroda State (2,200 acres) and also in Central Pro-ices. *Bors* are distributed on a wide area in the Bombay Pre-ency. In the Khandesh districts the cultivation of *bor* is ncentrated in Shirpur, Erandol and Jalgaon talukas. It is o grown in Ahmednagar, Satara and Sholapur districts. the Konkan tract some choice *bor* trees are found in the inity of Bombay town and Alibag. In the Gujerat districts edlings of wild *bor* are grown on a fairly large scale, and dded *bors* are also gaining popularity.

The *bor* occurs in several temperate regions of both the mispheres, and in the Tropical parts of Asia and America. ank N. Mayer, Agricultural Explorer, was responsible for e introduction of scions of large fruited jujube varieties in the nited States of America in 1908, and this work has now stimu-ted a great deal of interest in the culture of jujubes in Cali-rnia and Texas. It is largely grown in Afghanistan, Persia, menia, Syria, Burma, Malacca, Australia, Malay Archi-lago, Mediterranean regions and China. It is said to have en introduced into the Eastern Islands of the Amboyna group Ramphius. Its introduction in Arabia and Egypt seems to recent. It is believed to have gone to Zanzibar from Asia. ijube is an important fruit for dry Tropics, sub-tropics and able areas. In Russia (12) its cultivation in the dry sub-opical regions is given a place next to pistachio and almonds.

China is perhaps the most important country for the cul-ation of jujubes. There the fruit is known as Chinese or Chinese date. There are hundreds of varieties of jubes grown in China. It forms one of the principal fruits Northern China, and has been cultivated there many nturies before the beginning of the Christian Era. David airchild (8), Agricultural Explorer of the United States of merica, Department of Agriculture, wrote in 1918, "The Chi-se jujube is practically a newly discovered fruit tree so far as merican agriculture is concerned, for although, there are seed-ng jujubes in various public parks and door-yards, which doubt-ss are the result of early introductions through missionaries

in China, the importance of the large fruited grafted Chine varieties was only begun in 1906". Some valuable observa tions have been recorded on this fruit by the Bureau of Pla Introduction in the United States of America. This Burea seems to have succeeded in selecting suitable types for the Amer can market. Dorsett (6) recorded in 1916, "The jujube fro China is possibly as promising a plant commercially for Cal fornia and the semi-arid south and south-west as any of the oth valuable crops and ornamental plants that have been introduce from the Far East. The experimental tests made with th new alkali and drought-resistant fruit tree at the Chicag Plant Introduction Field Station to determine the possible valu of strains and varieties that have been introduced from amon the several hundreds known to exist in China, have been ver satisfactory. The fruit of the better varieties is fully as large as large prune, and reddish or mahogany brown in colour whe ripe."

The *bor* trees attain a considerable size. It is observed i Central India that a tree measured about eighty feet i height, sixteen feet in girth at about five feet from th ground, and a girth of twenty-five feet at the base. In th Punjab and Madras, some varieties often attain great heights an girths of about ten feet. In Florida jujube trees attain height of twenty-five to thirty feet (10). Some of the grafted varietie have gnarled stems and display a tendency to spread on th ground. The large dimensions attained by the trees in Indi as mentioned above, refer only to seedling trees. The tree in the Bombay Presidency are generally of a medium size rarely attaining about half the size of the seedling trees in othe parts of India. In regular seedling plantations in the Gujera and Khandesh districts, the *bor* trees are smaller, becau perhaps they are younger, than the isolated trees growing wild

Varieties and classification

In Western India a study of the various varieties of *bor* ha not yet been fully made, as the fruit is considered to be c comparatively minor importance. The chi horticultural types prevailing here are the sma large-stoned round-fruited type, the large ova fruited type and the stoneless small round-fruited type. The fir type is the wild local variety, while the second is the more flesh and popular cultivated one. The third type has lately bee

covered and is attracting the attention of the grower. It has no ne inside the fruit as its name indicates and it can be chewed ole. Besides the aforementioned chief varieties, there appear be a number of less known varieties yet to be explored l exploited. A variety called *Kotho*, introduced from the var State, is used for taking scions in the Jagudan tract of the oda State. The fruits of this variety are not much infested insects, which are so common on other varieties. There is a od variety of *bor* known as *Meherun bor* near Jalgaon in the st Khandesh district which too is believed by some to be fairly istant to fruit fly attack. In the Punjab several types of are reported to be under cultivation, especially in the parts of Gurgaon and Hansi districts testifying to the pularity of the fruit in those dry areas. A good deal of provement in the choice varieties of the Punjab *bors*, seems to ve been achieved during the Sikh rule, when perhaps no ier fruit was within the easy reach of the general public. It further believed that most of the choice trees were then otected in order to supply fruit to the Royal Household. There a variety of *bor* which resembles in shape a chilli (*capum*) fruit, and is tasty even when green. This was induced by one of the authors into Bihar from the Central ovinces during 1934. This variety has attracted some atten-n at Sabour.

l and climate

Bor trees thrive on a variety of soils and will grow and it in many ill-drained and poor soils, better than several other fruits. In California and Texas it is stated that the jujube grows luxuriantly on sandy m soils, but appears to prefer slightly alkaline soils (21). Sandy ms which are neutral or slightly alkaline and are well culti-ed are said to furnish the most suitable media for its growth l fruit production. The *bor* grows best in hot and dry cli-tes. Excessive atmospheric humidity is a limiting factor ts successful cultivation in many parts of India. The differ-e in foliage, size and pubescence of leaves is emphasised by the e with which the tree thrives even under conditions of drought l poverty of soil. Shallow light or medium black soils, h good drainage, are selected for planting *bor* in the nbay Presidency.

In Russia, the jujube is propagated by seeds, cuttings from the

roots, and grafting. If propagated by seeds, the seed c has to be broken or cracked, without injuring the embr

Propagation

otherwise *bor* seeds germinate after a long tir In California, *bor* seeds are often stratified sand and kept in a warm place for three or four weeks befo they are sown. Thomas (21) reports little success in rooting stem cuttings. Root cuttings of four to six inches, and having diameter of not less than three sixteenth of an inch were succe fully rooted. Budding proved unsatisfactory in the Uni States of America, but has been found to be an easy matter the Punjab and other parts of India where even ring or fl budding has been successfully practised. Most success method of propagating the jujube is by whip grafting. Ben and Field grafting are both followed. The latter is som what slower but the plant can be secured at less cost by t method. The wood used for grafting should be the p season's growth. It should not be much smaller than a le pencil as smaller wood does not produce good plants. T small side branches which bear the leafy deciduous branch are not suitable for scions. After grafting, it should carefully tied with raffia, waxed, and allowed to callus in dar moss in a place having a temperature of 40°-50°F. In abo 3 to 4 weeks the callusing will have progressed sufficient to allow planting in the nursery. The plants should planted in the nursery and the grafts completly covered wi soil by heaping soil arround it. This will prevent drying o and is absolutely essential for success. In the Punjab, the juju is a regular nursery plant in many places. Rootstocks of wi jujube plants are carefully raised and budded to choice varieti Budded *bor* plants are sold like grafts of other fruit trees such mango and orange.

Budding of *bor*

In Western India the *bor* has so far been commonly pro gated by seeds. Of late, budding of choice varieties on w rootstocks is gaining popularity. As a result trials made here during the last few years has been found that all wild plants of *bor* and *Chani bor*, in t districts of Surat and Ahmedabad can be worked upon with bu of choice varieties. The method of budding is simple. Plants a headed back in the months of February or March, leaving abo a foot of the stem above the ground. From below the cut e

· sprouts arise. The strongest shoot alone is retained, and the ·rs are cut out. When this shoot develops a thickness of half inch at the base it can receive a bud. It generally takes about › months for such sprouts to be ready to receive the bud. It is, refore, sometime in the month of April or May that budding ·rations commence. Buds are selected from one season wood the choice kind. Bud-sticks are immersed in water for a · hours before the buds are removed for use. If the buds re-in green for a period of seven to eight days after insertion, :an be taken for granted that they are "taking". Ten days er budding, if the buds continue to be green, the rootstock :ut off about four inches above the point of insertion of the d. Buds sprout after about twenty days. When the bud ›wth is about six inches long, its terminal bud is nipped off to courage lateral branching. Within a year this growth develops o a small tree, which can yield a harvest of about four to six unds of fruit.

ılture and pruning

In the Gujerat districts one-year-old seedlings are budded December in the orchard site. The local practice is to plant seedlings of wild variety in the orchard sites at twenty feet distance from each other. year later these are budded upon, as pointed out above, during e month of December. Budded rootstocks have to be properly rthed up and a basin made around their stem to give support the stem and to hold rain water. The plants are manured ·on after the buds sprout at the rate of two or three baskets 0--60 lb.) farm yard manure. At the beginning of the mon-›n, two pounds of common salt are given to each tree, and the owers raise a circular mound of earth to strengthen the base trees to withstand strong winds. Ploughing between rows of ·es is done once in the month of September. In the first few ars of the plantation, an inter-crop of castor (*Ricinus communis*) grown. Where there is no regular plantation, the self-sown edling trees are pruned close to the ground in the month of .ay. The new sprouts that spring up are budded upon with ·ions of superior varieties in the month of July, after the atmos-ıere is moistened by the first rains. Pruning can be practised ı the branches of *bor* trees once in two years, more or less in the me manner as the grape vines or guava plants are pruned. maller shoots are pruned back to their base leaving a short

stump. This forces new fruit spurs and increases the yiel There is no regular cultivation of *bor* in any of the Deccan ar Konkan districts. *Bor* is generally grown in Konkan for hedgir purposes. In some places in the Satara district it is complain that the wild *bor* trees on which superior varieties have be budded, put forth vegetative growth only, and bear fruits sp ringly. This seems to be due to the fact that the wide expan of the root system of the rootstock tree brings ample nouris ment to the new bud growth, which takes some time before matures sufficiently to bear fruits. Treating such trees with heavy dose of bone meal about the beginning of the monsoo may be found useful to induce them to fruit.

The seedlings usually begin to bear from the third or th fourth year. *Bor* trees flower in June. The fruits ripen in th

Bearing

cold weather in the Central Provinces and ar available in the market from the beginning November (13). It is almost the only fruit in the market in Feb ruary and March, after the orange season has closed, and othe fresh fruits become scarce. December to April is the bearin season for *bors* in South India. *Bor* is, therefore, specially prize because of its availability in seasons of scarcity of other fruits In Florida (10) jujubes ripen from July to September.

Side by side with the varieties of *Zizyphus jujuba* anothe wild bush of the same genus, known as *Z. rotundifolia* grow extensively in Gujerat. It is seen growing very commonly in th

Chani bor

Northern Gujerat. In the districts of Ahmeda bad, it is a common bush in the wilds. I seems to flourish on all sandy slopes and is extremely xerophyti in character. Its habit is straggling. It rapidly grows b means of root buds. It covers large circular patches and is ofte considered an obnoxious weed by cultivators. Every year it cut, but it is difficult to eradicate it. Instead, the stump grow with redoubled vigour. It has small leaves and possesses shar prickles in pairs on its twigs. Like many other wild bushes i does not even make a good fuel. It bears very small fruits wit little edible pulp, which is acidic in taste. It is the shepher or the cow-boy who might value this fruit in normal years During famine days, however, the fruit is collected by villager for "*Barchumi*"* purposes. *Z. rotundifolia* is thus essentially

*It is ground and used as meal.

STONELESS *BOR* TREE.

Facing page 41

ed. During the past few years this wild plant has been ted for its value, as a rootstock for choice varieties of *bor*, the tivation of which is much desired in the Gujerat division. oservations extending over many years now lead to the consion that this obnoxious weed as it is considered, makes a very uable rootstock for the *Z. jujuba* and its varieties. This wild rub takes the bud very readily and the budded plants quire little further care, except protection from strong winds, grow and bear fruits. The quality of fruits produced is very isfactory and fetches as much value as fruit of similar varieties ised on *Z. jujuba* rootstocks. In fact, plants budded on this otstock are easier to handle as they do not grow into large ees. Whether this dwarf habit of the trees is due to the inence of the rootstock remains to be investigated. The method at has been adopted successfully in budding this bush does not aterially differ from the one adopted in budding *Z. jujuba* ants. This bush is headed back right to the level of the ground the months of February and March. Several vigorously growg young shoots are thrown up and in the months of April and ay these young shoots are budded at a height of about a foot om the ground. The 'T' method of budding is found success-l. All shoots which might sprout from time to time near and elow the bud from the rootstock are nipped off. When the ud grows into a shoot, five or six feet in length, the plant is rthed up to give strengtq against strong winds. The budded ishes bear fruit in three years. Fruit is harvested from Decemer to middle of February. After harvesting is over in April id May the budded plants are pruned. All growth is cut down the base from where new sprouts develop vigorously and bear ood fruit next season. Each bush thus budded fetches an come of about a rupee per season.

The Bombay Department of Agriculture has recently oserved that there exists a variety of *bor*, in which the endocarp of the seed does not develop into a hard stone as is usual with seeds of the common varieties.

toneless Bor

he fruit of this variety is round and small in size like that of the ild type, but one hardly feels the stone inside it while chewing e ripe fruit. This fruit dries well. The original tree of the oneless variety is growing near the Surat city. The Ganeshhind Fruit Experiment Station, Kirkee, has now raised trees of

this type and can supply bud sticks to the public. During th last few years, a large number of these buds have been distrib ted to cultivators in the various parts of Western India.

Uses of the *bor* tree

The *bor* tree is not only the source of a much relishe fruit but yields other economic products as well. The Chines jujube (21) is utilized in a number of way Fruits are eaten fresh, semi-dried, baked i bread, stewed with rice, millet or meat. As a candied c crystallized fruit, it is very delicious. In the United Sates c America and China, it is extensively used as a sweet after th fruit is cooked in syrup, which procedure is also involved i candying or crystallizing it, after puncturing the thick ski thoroughly and all over to permit the penetration of the syrup The leaves of *bor* are used as fodder to feed livestock and ar said to increase the milk yield of milch cattle. This belief c farmers has yet to be confirmed by experimental data but i seems to be a well established fact in the case of sheep and goats. The question of fodder supply during periods of fodde scarcity engages a good deal of attention of the agricultura population of India. It is observed all cattle eat *bor* leave with relish. The chemical analysis of *bor* leaves disclose tha they contain high phosphoric acid and a large amount o mucilaginous matter. There appears to be nothing in them which would make them objectionable as a fodder. Althoug these leaves may not compare favourably with other fodder like maize, they are certainly valuable as an emergency fodder The phosphatic contents of young fruits before they develop stones, cannot but enhance the fodder value of leaves mixed wit tender fruits. The thornless varieties with a large leaf surfac are more suitable for use as fodder than the thorny *Malla* o *chani bor*.

In all parts of India (24), the *bor* tree is known for the qualit of its wood. Persian wheels, agricultural implements, well curves, oil seed crushers, legs of bedsteads and various othe articles are made of its wood. It is also considered a valuabl timber for constructing huts and buildings. This wood is con sidered to be fine and close-grained. It makes excellent char coal and has a high calorific value. In the districts of Satara the branches of *bor* are used for fencing purposes by the villagers As they are thorny and cheaply available, their use in hedges

ly appreciated. The extension of the cultivation of *bor* in Deccan and dry-rainless tracts might serve a useful purpose he present campaign of rural uplift as this tree is a source of t, fuel, fodder and fencing.

Data obtained indicate that by proper addition of acid and tin, a good jelly which still retains a fairly large amount of orbic acid can be made from jujubes (fruit of *Zizyphus vulga-*. They also suggest the possibility of using this fruit in com-ation with other fruits as a means of increasing the ascorbic d content of the product (20).

rvest and storage

With the exception of some varieties, which lend themselves be eaten even in their greenish state, the *bor* as a rule should be picked, when they are still crisp, but have developed a light yellowish scarlet or brownish e on the outer skin. Wardlaw (23), summarising the findings other workers, suggests that jujubes should be picked when first brown spot appears on the skin. The small fruits borne the seedling jujube trees in this country are, however, fit to eaten only when the flesh is soft to the touch and the skin has ained the full colour. Overholser and others (17) have found at at 32°F jujubes can be stored in open containers for 45 ys, but the skin cracks and wilts, when the fruits are kept in sed containers.

od value

Blasdale (1) gives the average composition of the pulp of dried jube from the Chinese Quarter of San Francisco. Church (5) reports the results of physical and chemical examinations of the pulp of fresh and dried ubes grown at the U. S. Plant Introduction Garden, Chico, lifornia. (Also see pages 416, 417 and 418.)

Percentage of ash in the seed-free pulp of two varieties and alyses of ash are here given. The high alkalinity of the is shown by the marked predominance of basic constituents.

ommercial value

The *bor* is a dry crop and little attention is paid to it, ex-pting ploughing and cleaning the area of the plantation in some tracts like Khandesh only. The land used for this crop is generally inferior, where rhaps other fruit crops would not be successful. It is difficult state with accuracy the exact cost of cultivation in detail, as r trees are mostly scattered about. There is, however, little oubt that the cost of cultivation is very low in comparison with

Composition of jujube pulp

	Samples	Water	Protein	Fat	Acids as Citric	Sugars reducing	Sucrose	Pectin	Fibre	Ash
		%	%	%	%	%	%	%	%	%
Blasdale										
Dried	1	13·44	2·93	—	—	42·19	13·06	—	—	1·73
Church										
Fresh	10	65·36	1·16	0·28	0·43	11·91	12·22	0·36	1·27	0·85
Dried	4	16·24	4·42	—	1·15	39·24	2·78	—	3·17	2·32

Composition of Ash of Jujube pulp

	Ash	K_2O	Na_2O	CaO	MgO	Fe_2O_3	MnO	P_2O_5	SO_3	SiO_2	Cl.
	%	%	%	%	%	%	%	%	%	%	%
I	1·03	56·40	1·65	5·42	4·46	0·12	1·11	1·04	1·85	0·28	4·08
II	1·42	54·78	1·29	5·60	3·53	0·12	0·99	0·64	1·40	0·27	3·49

Benoy quoted by Winton and Winton (25).

The food value of *Ber* (*Zizyphus*) in India is gi
in the following table :

HECKED 2009

RIFIED 2013

Name of food	Ber Zizyphus
Botanical Name	*Zizyphus jujube*
Moisture %	85·9
Protein %	0·8
Fat (Ether extractives) %	0·1
Mineral matter %	0·4
Fibre %	—
Carbohydrates %	12·8
Calcium (Ca) %	0·03
Phosphorus (P) %	0·03
Iron (Fe) mgs. %	0·8
Calorific value per 100 gms.	55
Carotene (International Vitamin A Unit per 100 gms.)	70
Vitamin B (I.U. per 100 gms.)	—
Vitamin C mgs. per 100 gms.	—
Calories per ounce	16

.come. The yield of a fairly grown *bor* tree ranges from two
ree or even more maunds of fruits annually. The large
fruit fetches a high price.

he *bor* trees are infested with several kinds of insect pests,
the commonest are the fruit borers. Fruit Fly, *Carpomyia vesuviana*. B is the most harmful, particularly to sweet varieties. A few eggs are laid at a time in each fruit. A single fly may lay eggs in

and diseases:
fly

ge number of fruits. The eggs are small, elongated, pointed
oth ends, and white in colour. On hatching, the maggot
ows into the fruit and remains feeding inside and resembles
rain of fine rice when fully grown. The maggot goes
eeding on the pulp and makes small holes in the rind of the
t to admit air for respiration. Bigger holes indicate that the
-grown maggot, has come out from the fruit for pupation
he soil. The pest is active from November to March, during
ch period two or three broods appear. It hibernates in the
al stage in the soil during summer. Pupation takes place at
erent depths according to the condition of the soil control:—

1. After the fruiting season the surface of the soil underneath the tree should be burnt by spreading dry grass and leaves so as to kill the pupae.
2. If possible bait spray of lead-arsenate powder 4-5 ozs., sugar or molasses four pounds, water three gallons may be tried during the prevalence of the fly. Commence spraying about three weeks before the fruit ripens and keep on baiting every twelve days and always repeat after rains. Spray for some time even after the fruit is harvested.

It may be possible to spray small plants where the *Chani bor*
used as rootstock.

No serious damage is reported on *bor* trees from fungus
seases in Western India, except from a species of *Cladosrium* which attacks only the leaves.

The *bor* tree is used for rearing lac insects (*Tachardia laccad.*)
the Central Provinces and in Madras Presidency. Some observations in this direction are also made in the Bombay Presidency. The wild *bor* forms a useful host plant for the lac insect (19, 15,
). It is expecte[d tha]t in due course of time, when the

ac rearing on *bor*
es

price of shellac in the world market improves, the use of wild in India will be fully realised by the cultivators. Lac rear has attained most prominence in Bihar than in any other p vince not excluding the Central Provinces.

Candied *Bor*

Large sized fruits which have just begun to turn yellow pricked with any suitable hand-worked device which ha large number of thick pinlike prongs stick out. This pricking is followed by salt cur by steeping in 2% salt solution, adding calculated amount salt so as to increase the strength of brine by 2% every 24 ho till a final concentration of 8% brine is reached. The salt cu fruit is then boiled till it becomes soft. It is washed thoroug to remove the salt absorbed. The fruit is then put in boil syrup of 38° Brix containing 0·1% citric acid which is ag brought to a boil and the vessel well covered. The strength the dipping syrup is increased to 35°, 40°, 45°, 50°, 55°, 60° a every 24 hours and later to 65°, 70°, 75° after every 48 or hours. The syrup is then drained and the candied fruit dr on wire gauze trays preferably in the shade.

Drying of *Bor*

Fully ripe fruit is washed and given a little dip in b water, drained and left in the trays to dry in the sun. E should be made to provide hygienic cond for drying. It takes about 8-10 days fo fruit to dry. The dried fruit tastes very sweet and is rel very much as a desert fruit.

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